INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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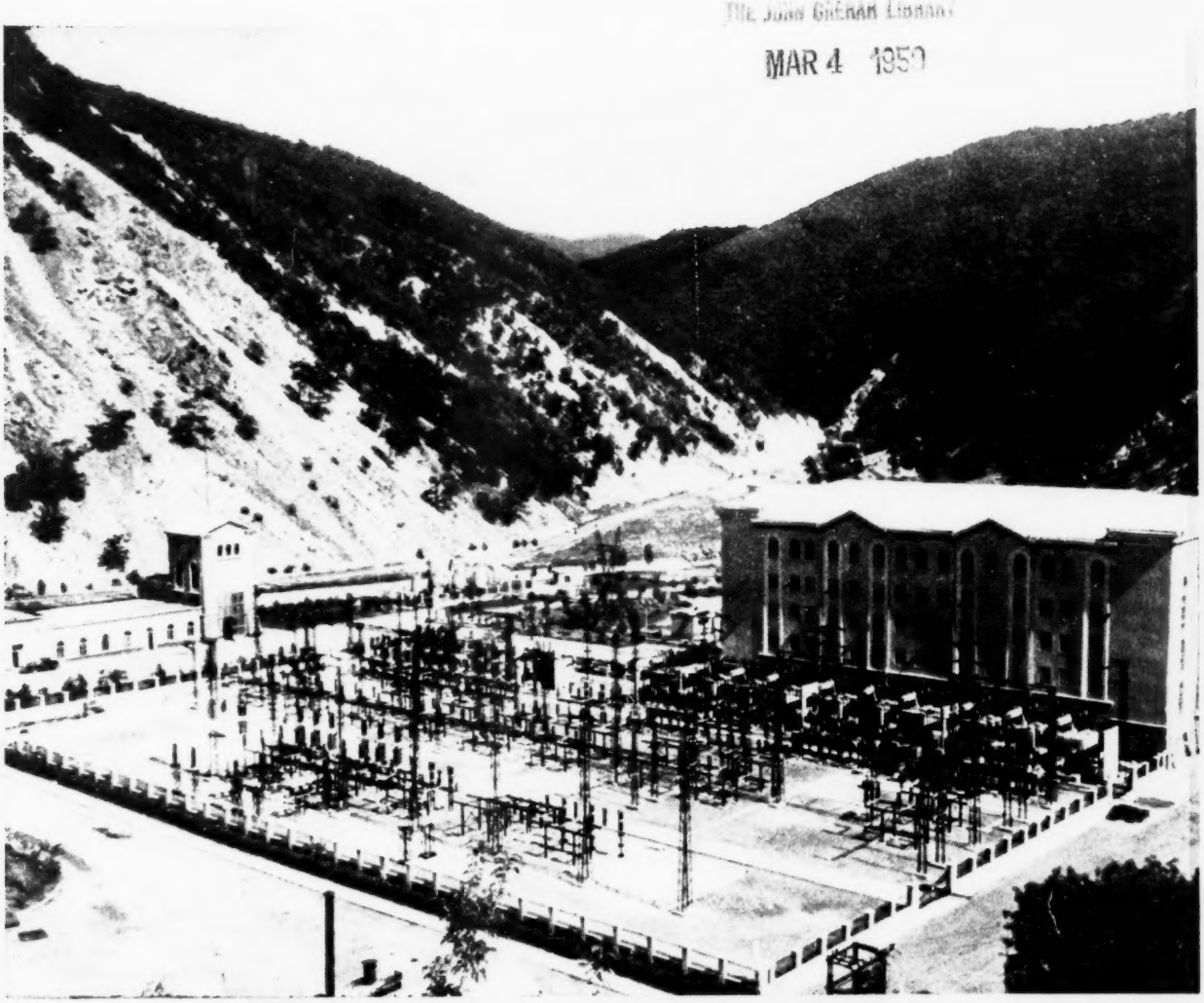

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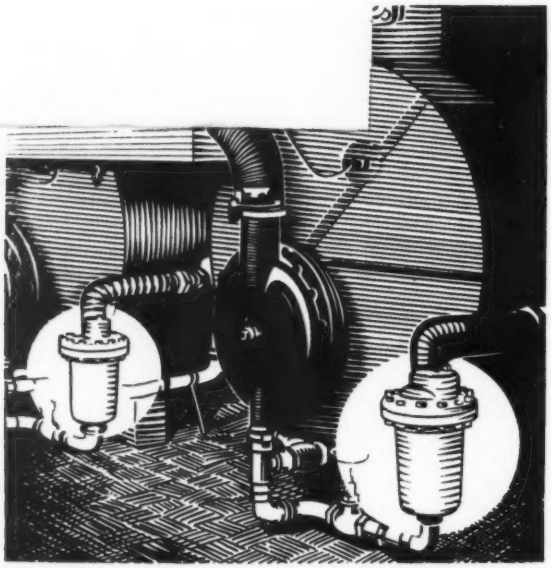

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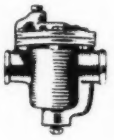

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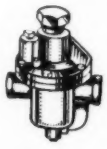

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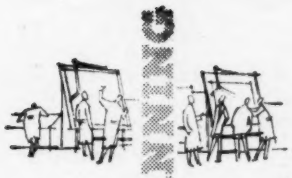

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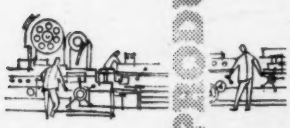

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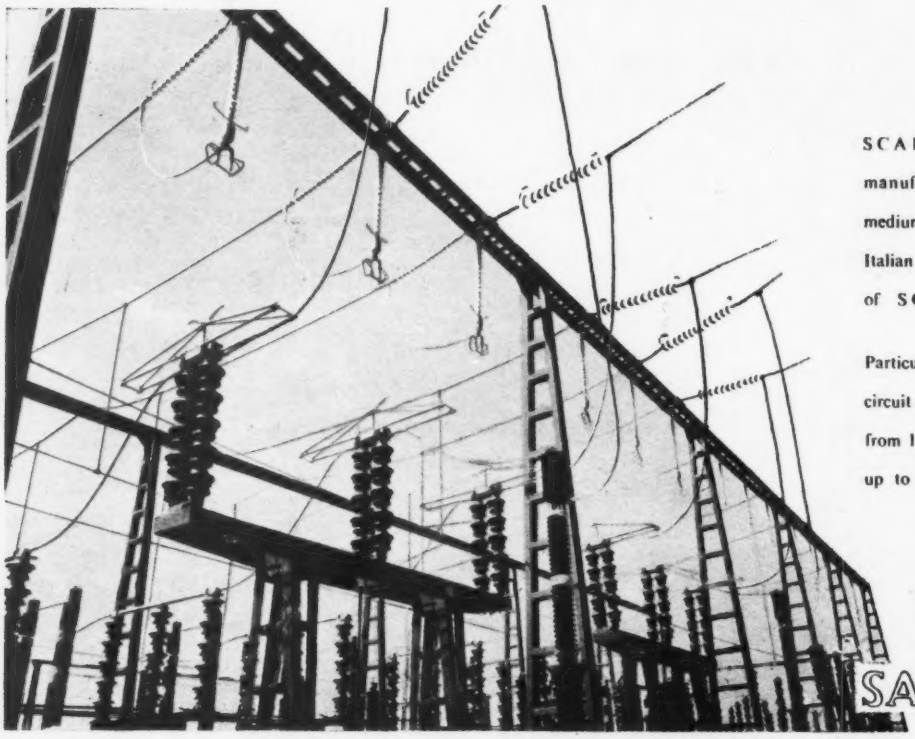

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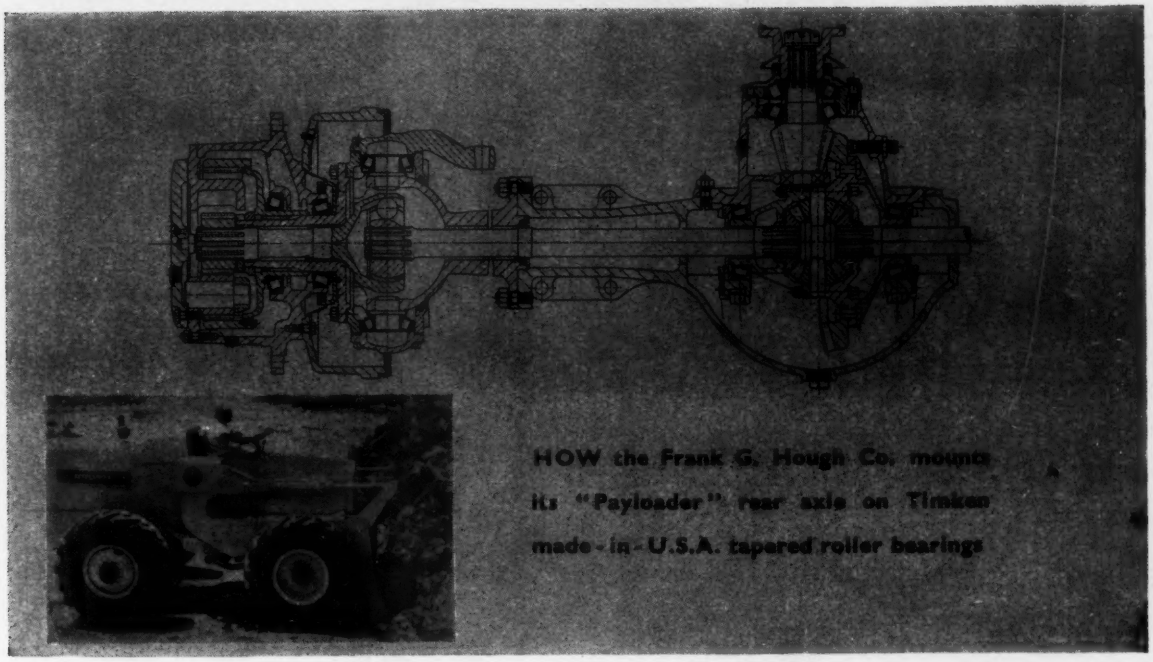

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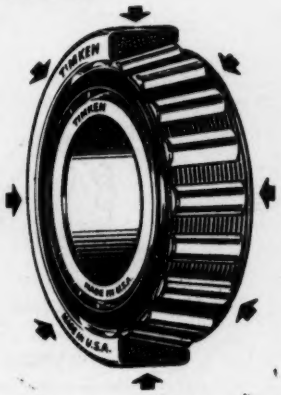

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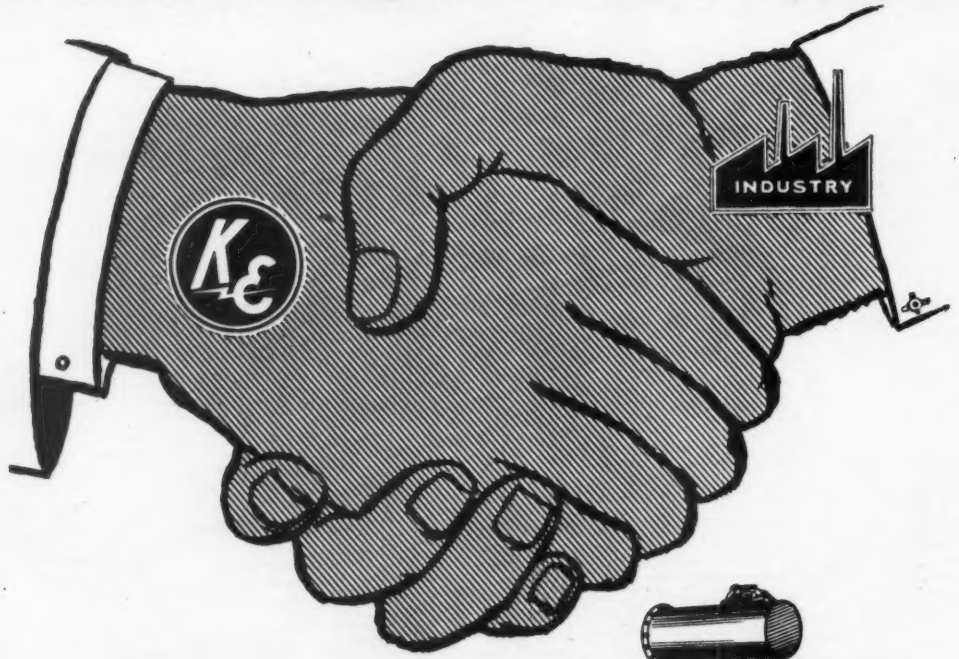
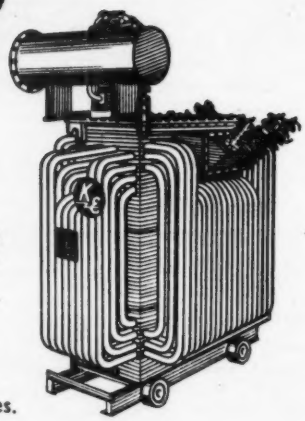


KIRLOSKAR ELECTRIC ON THE ONE HAND AND INDUSTRY ON THE OTHER



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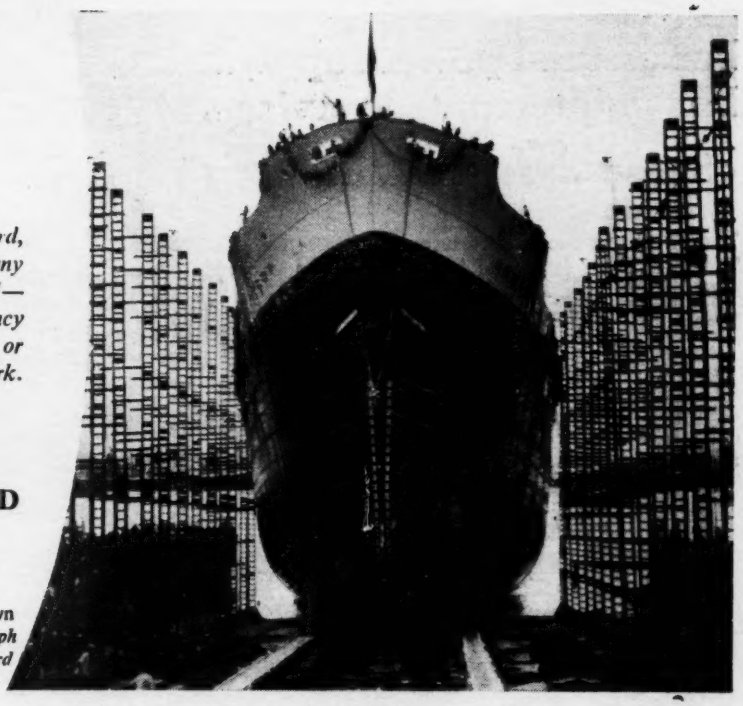
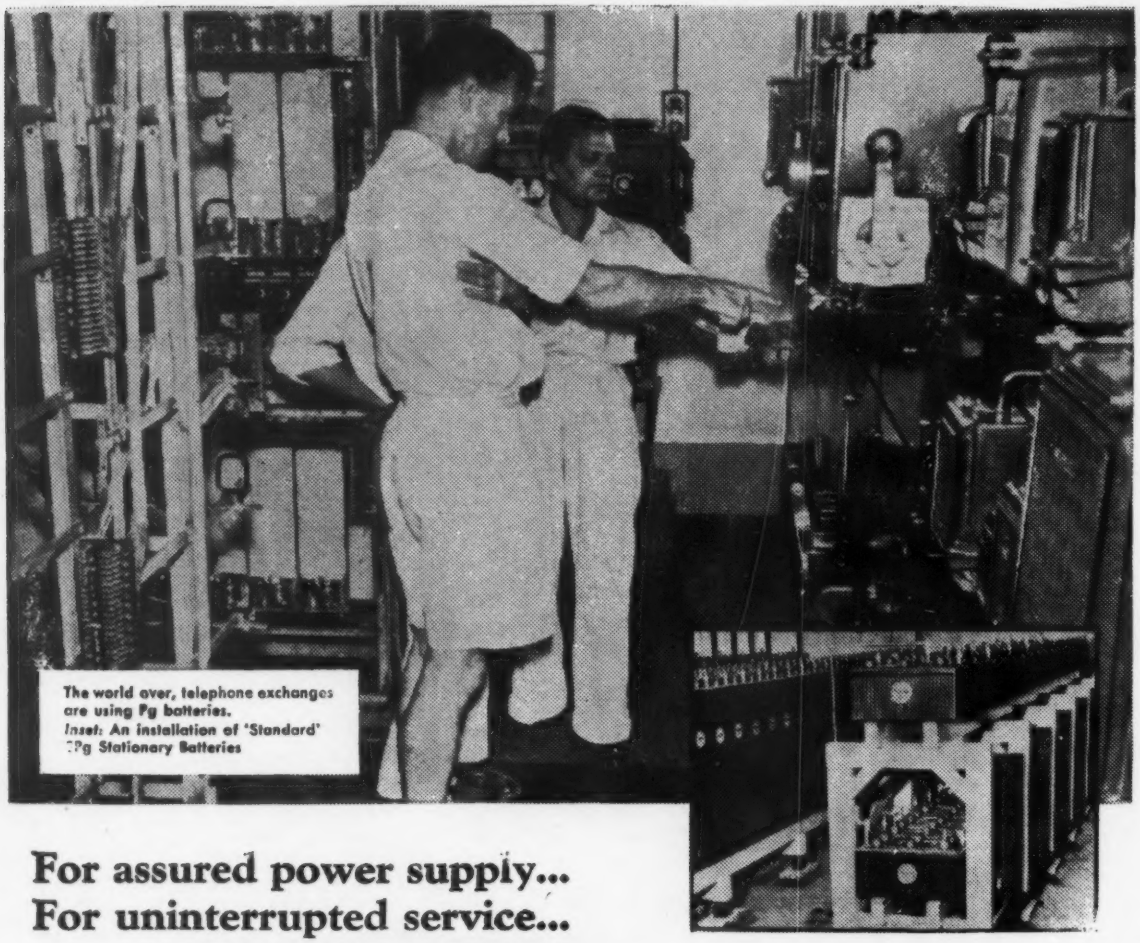


M. V. "RAJKUMAR" gliding down the slipway on 5th July, 1958. *Photograph by courtesy of the Hindustan Shipyard*



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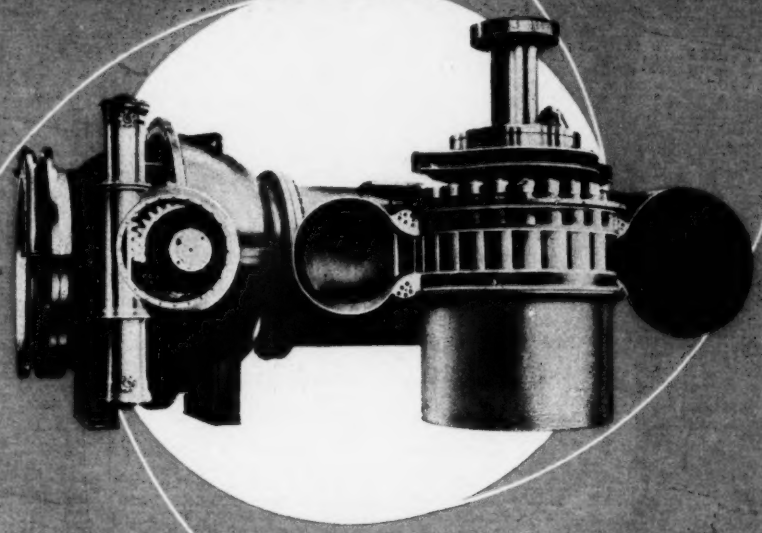

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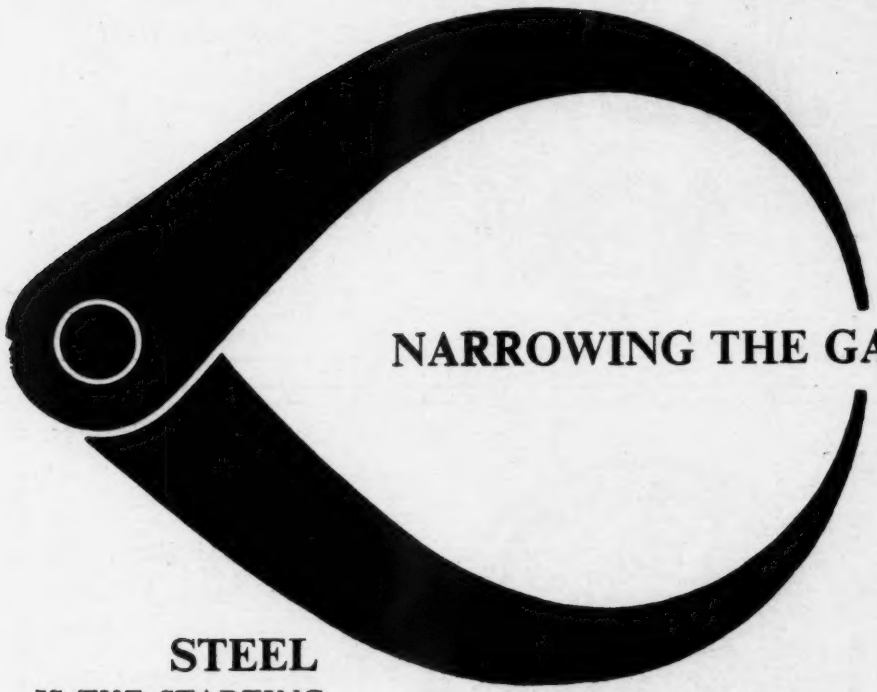

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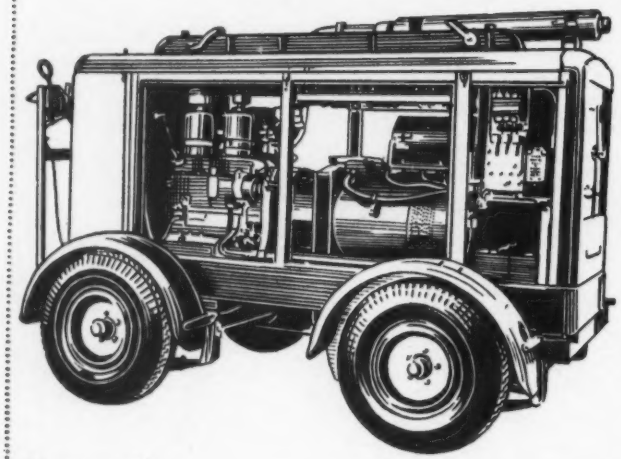

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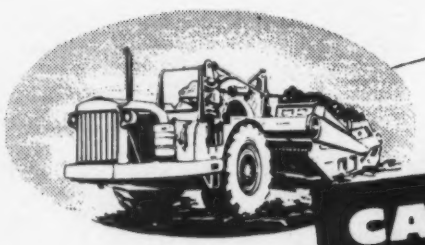

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : K. K. Sinha — P. K. Menon : Mg. Editor

VOL. VIII — **NOVEMBER 1958** — **NO. II**

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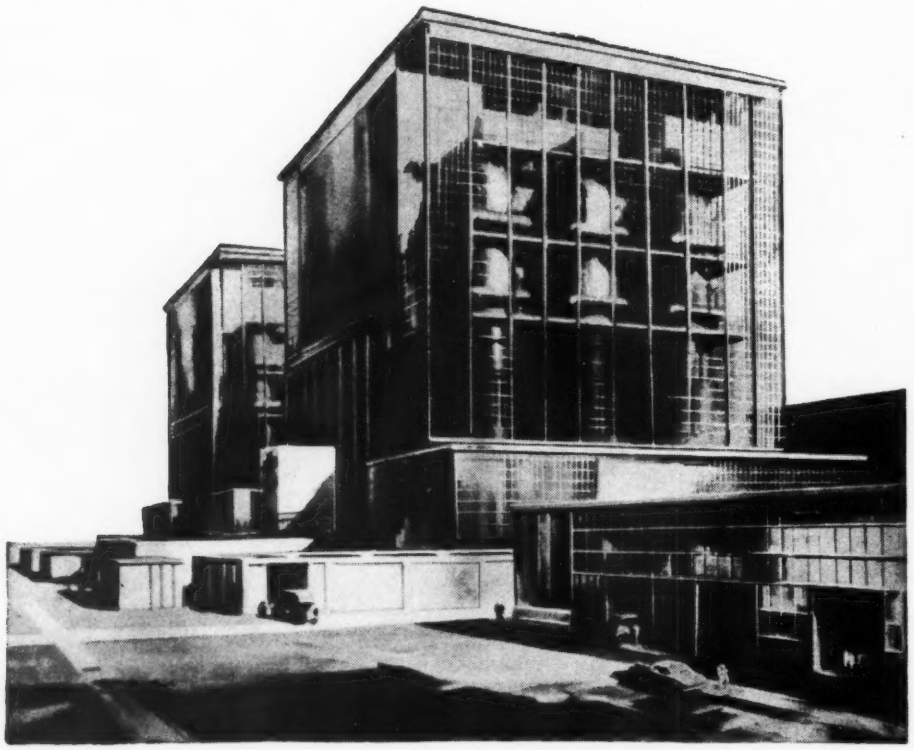

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Being the Presidential Address delivered at the twentyninth Annual Meeting of the Central Board Irrigation and Power at Delhi Nov. 17, 1958.

By Prof. M. S. THACKER

It is my privilege to welcome you to this twenty-ninth annual meeting of the Cntral Board of Irrigation & Power. The members of the Board and myself are most grateful to you, Mr. Prime Minister, for the honour you have done us in acceding to our request to inaugurate this session. We are aware of your abiding interest and zeal in planned construction and development, and the trust you have placed in the engineers of the country to influence further, and mould the economic progress of the nation. We, cn our part, are fully consicious of our responsibilities in the discharge of which not only knowledge, skill and experience, but also devotion to work and social awareness are called into action. The nation has set a high premium on irrigation and power projects, because, while the former provide the means for augmenting vital food production, the latter constitute the life blood of industrial development.

Our economy has received the praise of experts and knowledgeable persons. Yet we have to face food deficits and large sums of money have to be spent on importing food. Adequate food production for the requirements of a growing population must receive the highest priority And the technical aspects as pertaining to our specialities have a major part to play in this national problem.

This year also there have been unusual and heavy rains in several areas, causing in their wake, apart from heavy loss of agricultural crops, severe water-logging. Water-logging, besides leading to epidemics, is a serious menace in its cumulative effects, such as increase in the salt level of the soil and low fertility. Drainage problems have to be carefully surveyed on a natien-wide scale and effective remedies found for avoiding large-scale waterlogging.

There are also certain aspects of work germane to the development of river valley basins to which I may refer.

India's water wealth is considerable : in terms of annual run-off, the total resources amount to 1,357 million acre feet; and in terms of power potential, the resources are of the order of 40 million kilowatts. Of this, only 6.9 per cent is employed for irrigation purposes and hardly 3 per cent is harnessed for power generation. Though the area irrigated in India is considerable, yet it constitutes less than 20 per cent of the cultivated land. These figures provide a measure of the task awaiting to be accomplished in our objective of optimum utilization of this primary natural resource.

There is in India much more water than is needed in the foreseable future but it is not evenly distributed; nor is it available at the appropriate time nor in the quantity required. Storage and planned utilization of water have therefore assumed importance. Much has been accomplished in this direction during the last decade; for instance, in 1946, the water storage capacity in the reservoirs was hardly 10 million acre feet. The projects already completed and those which will be completed by 1961 will raise the capacity to 80 million acre feet. In 1946, the area under irrgation was 46 million acres; the target to be reached by 1961 is 87 million acres, including 19 million acres due to minor irrigation projects in the First and Second Five Year Plans. In the field of power development, the installed capacity was 2.3 million kilowatts in 1951; it will be trebled by 1961; by 1966, the generating capacity is expected to reach 15 million kilowatts. These developments, considering that we started almost from scratch in the first Plan period, are really achievement mnets of which we may well be proud.

It is not always realised that the development of water resources implies a knowledge and understanding of various physical, social and economic factors. We should also understand the ways of nature and plan in consonance with it. Precise data on rainfall, river flow, sedimentation, water discharge, ground water level, subterranean drainage surface evaporation, geology and topography of dam sites and allied matters are necessary. Problems of river training, flood control, soil conservation, soil erosion and drainage are closely

The Prime Minister inaugurating the 29th annual session of the Central Board of Irrigation and Power at Vigyan Bhavan, New Delhi on Novemher '17.

interconnectd with the execution of irrigation projects Soil surveys, regional crops, agricultural practices are other aspects to be taken into consideration. The social and economic impact of projects on the poulation also requires study.

In the formulation of irrigation projects, the primary consideration is the enhancement of the productivity of the land. Other considerations, like power generation, navigation and flood control are also important, and in effect, practically every one of them has become a multipurpose project. It was realized at an early stage that to derive quick benefits, stress should be laid on minor and medium projects, for though the benefits are relatively small, they take less time for completion. Thus along with the gigantic projects which provide water cheaper than the small ones, a a large number of minor and medium projects have been taken up and some measure of success has been recorded in the completion of such projects. I hope emphasis will still continue to be placed on minor irrigation works for some time to come.

Though there is a clamour for increased irrigation facilities, there appears to be no proper synchronisation between their availablility and utilization. Taking into account the short period that has elapsed since the development of river basins, it is too early to venture an opinion on this question. Nevertheless an assessment of the facilities provided and the incentives offered to cultivators to utilize them is called for. The provision of efficient distribution systems to carry water to the cultivators' fields and rationalization of irrigation cess are among the requirements which need to be looked into. The education of the cultivator on on the benefit of irrigation will also prove helpful. I understand that a Committee is already examining the various requirements for stepping up the use of irrigation water. I would however request the members of the Central Board of Irrigation and Power to study the existing lacuna and find ways and means of reducing the time gap between the provision and utilization of irrigation facilities.

The blocking of the natural flow of rivers and streams for creating artificial lakes has brought in its wake several new problems and aggravated some of the known ones. Silting up of impounded water stretches waterlogging in fields, soil erosion, flood damage, and changes in river course are among them. I do not propose to deal with all these problems in great detail today but I must emphasise the need for their systematic investigation.

One of the major dangers which threatens the life span of river valley projects is the gradual siliting up of the reservoirs. Though there has not been any extended experience on this,some of the observations on Lake Mead and other reservoirs in USA show the necessity for paying great attention to this problem. A secondary effect of trapping the silt in the reservoir is flooding of areas lower down which were not subject to damage before. This is due to the clear water emerging from the reservoir picking up the silt on its way and depositing it again at another point lower down. Thus the sedimentation of reservoirs and alterations in the regime of rivers lower down are problems which require great attention.

Many Indian rivers carry heavy loads of silt during the monsoon months as the rush down hillsides and deposit their load on the beds of comparatively stagnant water stretches. Model experiments, designed to study the nature of currents in places where silt deposition is likely to occur and trials on silt ejection through outlets by turbidity currents are being carried out in our research institutions; observations at dam sites are also being made. Investigational work, however, must be considerably enlarged if the potential danger which silting holds out is to be avoided.

Various proposals have been mooted to combat soil erosion, but no permanent solution seems to be in sight. The problem has been greatly aggravated by deforestation. Soil conservation, though slow, offers an effective solution for the erosion problem. The technique varies from region to region, and has to be worked out separately for each area. Research into the ways and means of rapid afforestation is called for, and alternate fuels in adequate quantities are to be found to eliminate indiscriminate felling of trees for use as fuel. Compared with the effort devoted to the construction of dams, the attention paid to soil conservation is little.

The President meeting the Delegates

Another problem demanding attention is the loss of water in reservoirs through evaporation, seepage and deep percolation. An assessment made in a major irrigation system, the Ganga Canal in U. P., has revealed that of the total supply diverted into the canal, 15 per cent is lost in the main canal, 7 per cent in the distributaries, and 22 per cent in the village water courses. The wastage in the last stage is particularly heavy and this can be minimised by attention to the layout of channels and sound managment. Some work has been done on the reduction of evaporation losses by the use of chemicals which spread out as a film on the surface. The results so far obtained are indicative of the possiblities and point to the need for further work on a more extensive and intensive scale, and the necessity for indigenous manufacture of chemicals for this purpose.

The water needs of crops can be determined with some degree of precision and supplies can be adjusted to meet the requirements. Agricultural and irrigation practices may, in certain cases, be reoriented to minimise water use. Spray irrigation may be adopted as an alternative to normal irrigation and this method has the additional advantage of obviating the risk of waterlogging. The main objective is to combine practice with knowledge and not be guided by rule-of-thumb methods. Work on rationalizing agricultural and horticultural practices has been in progress for some time in agricultural stations, and there is an urgent need to examine the accumulated results both with the view of bringing useful results into practce and to initiate investigations, where necessary.

In some of the methods employed for the study of engineering problems, experience and conjecture play a significant part. Radioactive isotopes offer a new research tool in such studies and their use would help in the collection of accurate data for guiding engineering practices. Uniformity in mixing and laying of concrete in dams, lining of canals to prevent water seepage, and mechanics of silt deposition and scouring are a few of the problems which lend themselves to such study.

Our progress in power engineering research has not been as impressive as in the irrigation field. There is ample awareness of the role of electric power in raising the living standards of the people. As I have stated earlier, the revision of the target for power generation to 15 million kilowatts by 1966, as against 7 million kilowatts originally planned illustrates the fact that in a developing economy, the power demand often exceeds anticipation

Rural electrification is gaining importance in India. From the point of view of economics, the extension of electrification into rural areas will not bring returns commensurate with the capital outlay, because of the lack of heavy load density. To the technologist, this offers a challenge: ways and means have to be evolved for reducing capital investment and minimising transmission and distribution losses.

The large power development envisaged in the near future and the setting up of the first heavy electrical plant manufacturing factory at Bhopal have accentuated the need for further research in the power engineering field. The report of the expert committee which as constituted to formulate the programme of research is now under active consideration, and I trust speedy progress would be made in its implementation.

The need for close collaboration in planning hydro and thermal power developments has been receiving attention. Atomic powers is round the corner, as it were, will become available within the next few years; and I venture to say that it will not be long before atomic power becomes competitive with conventional sources. The pooling of power generated by different production techniques through national grids would promote economy and raise the efficiency of distribution and use.

I have indicated in this brief survey a few of the more important problems which come within the purview of the Board. On an earlier occasion, in June this year, when the Board held its research session at Srinagar, I discussed some of the significant achievements of the Board during the current year. I will not cover the same ground today. The Board is seized of the importance of fundamental research as a means of acquiring knowledge basic to the planning, execution and operation of irrigation and power projects. Specific proposals for research schemes to be undertaken at the various engineering research institutions of the country have been formulated. Though the tempo of their implementation has not been fast enough, as we would like, because of procedural delays and other difficulties in the procurement of equipment and recruitment of research personnel, a beginning has been made. And I am happy to say that our dependence on foreign institutions for carrying out tests on various problems that arise in the course of the execution of projects is rapidly diminishing.

The heavy capital costs involved in engineering projects in respect of development of all resources necessitate thoroughness in investigations and a variety of factors outside the speciality of engineers, have to be taken into consideation. I would point out to my

fellow engineers the need for boldness of approach to the problems of resources development. Beaten tracks may be sound and have the sanction of tradition and usage; but great developments do not always come that way. Success attends on those who dare and act.

The Central Board of Irrigation and Power has three decades of active service to its credit and today it is the nation's repository of knowledge and skill on irrigation and power. It tenders advice on initiating and coordinating research, and collection and dissemination of information. The Board has extensive contacts with expert bodies all over the world; and it fuctions as the national committee in India for the International Commission on Large Dams, the International Commission on Irrigation and Drainage, and the International Association for Hydraulic Research.

The Board has an importance which is of special relevance to the nation's policy of 'progress through planning'. Some years ago, Lord Rutherford made a plea in the House of Lords for setting up what he called 'Pre-vision Committees' which would look ahead and see from the knowledge of recent advances the sort of things likely to assume importance in future. It is no good, he pointed out, having expert bodies unless notice is taken of their advice and incorporated into the fram-work of policies. And in the interests of efficinecy, the time lag between advice and execution must be abridged.

The Board, being consitituted of the top persons in the field of Irrigation and Power, is the body that can evaluate and decide dispassionately the merits of any particular project in the irrigation and power field. It is but appropriate that the Board should play a more effective role in the country's development of water and and power resources with which are tied up the problems of increased food production, and rise in the living standards of the people. We may consider how it can be made more and more effective. Perhaps, we might lay on the Board a statutory obligation to shoulder such a responsibility.

May I, in conclusion, refer to one of my distingushed colleagues, Mr. Kanwar Sain, who is retiring shortly. Mr. Kunwar Sain has been associated with the Central Board of Irrigation and Power since long. He has rendered valuable service to the cause of irrigation and power development in India. I hope we shall continue to have the benefit of his ripe experience in the Board's work. I also desire to express my indebtedness to my colleagues on the Board and the Executive Committee for their collaboration and to the staff, and the Secretary of the Board, Shri Baleshwar Nath, for cooperation in the conduct of its affairs during my tenure as its President.

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OF

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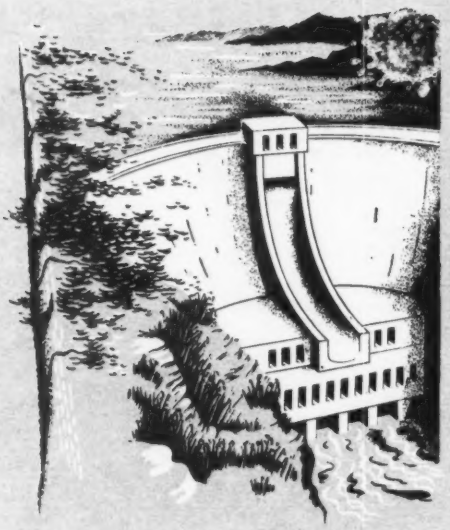

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Modern Developments in Water Power Engineering

By K. SEETHARAMIAH

The progress and civilization of a nation is generally measured by the amount of electricity consumed per capita in the country. Power is primarily important for the development of a country. How backward we are is shown by the annual consumption of about 25 per capita against a consumption of 5750 kWh in Norway, 4830 kWh. in Canada, 3220 kWh in U.S.A. 3140 kWh in Sweeden, 2790 kWh in Switzerland. This clearly indicates how much we are yet to advance to develop our country all round.

So far as India is concerned it is a known fact that coal resources are very limited. No doubt we have abundant quantities of inferior coal in the form of lignite but this may not be very economical at points far away from the pits. The oil resources at present known is not very promising. But India is blessed with mighty rivers along its entire length and breadth. The Indus, the Ganges, the Brahmaputra and their tributaries in the North; the Cauvery, the Krishna, the Godavari and their tributaries in South; the Mahanadi, the Tapti and the Narmada in the Central India and various small rivers of the Western and Eastern coasts are sources of aboundant power potential in the country. No systematic survey had been condcted regarding the available water power potential in the world. Based on the calculations made by the geological and hydrographic surveys, the power potential (water power) with minimum flow and hundred percent efficiency is about 645 M.H.P. and the table below gives the distribution among the various continents. The table also gives the developed power.

Table No. 1

Country	*Potential Power*	*Developed Power*
Africa	250 M. H. P.	0.7 M. H. P.
Asia	156 ,,	14.4 ,,
Europe	64 ,,	48.5 ,,
North America	90 ,,	46.4 ,,
South ,,	62 ,,	3.9 ,,
Oceania	23 ,,	1.8 ,,

In India the data collected by the Central Water and Power Commission show that the power potential is as much as 40 M. H. P. It is quite certain that further collection data in this direction will reveal abundant water power potential in our country. This source of power as it stands today is the backbone for the rapid industrialisation and advancement of our country. Water power has been very systematically developed in Norway, Sweden, Switzerland, France etc. Against the 40 M. H. P. which can be developed according to data available, we have developed hardly 1.5 M.H.P. It is obvious that in India water power should be developed very systematically taking advantage of the technical and scientific advancement that are taking place in other countries. Further India is in a better position as it can take advantage of the lessons learnt and experieences gained by other countries in this field. The latest development in the accurate calculation of yield by hydrological methods, the developments in the latest design of hydraulic structures and allied works, the utilization of modern construction equipments to expedite the construction, the advances made in the model studies, and the utilization of most modern turbines, the alternators, transmission etc., has put our country in a better position for the development of water power in a very systematic manner. Other developments that has taken place in addition to the above mentioned are:

(1) The increase in total capacity (2) the size of the units (3) Increase in the area of geographical coverage (4) Co-ordination with other forms of power and (5) Improvements in technical features etc.

Technical Improvements

A hydroelectric development comprises of a number of features depending upon the type of development. A plant may be a high head plant, medium head plant, low head plant, base load plant, peak load plant, run-

of-the-river-plant, pumped-storage plant or an underground plant. The essential features of a hydroplant are any combination of the storage reservoir water conductor system, generating station, tail race, the transmission lines and other allied structures. Considerable development has taken place in hydraulic turbines, generators, transmission line etc., and a brief description of each of these will be given in the succeeding paragraphs.

Hydrology

Hydrology has developed methods which would enable us to assess very accurately the quantity of water available from the basin for the development of power. Sherman's unit-hydrographs method of computing the flow, the use of mass curves, flow duration curves and the hydrographs are very powerful tools in the design of hydroelectric projects. Hydrology has enabled the engineer to predict the correct flow in the streams, assess the minimum flow, and the frequency of extraordinary droughts and floods. The statistical methods enable a hydrologist to make frequency studies of high floods and their magnitude such that the storage reservoirs could be provided with sufficient flood absorption capacity and adequate spillway. The exact prediction of the inflow will enable preparation of proper schedule for storage and regulation so that unnecessary spillway capacity is avoided, with proper regulation and operation of the reservoirs in multi-purpose schemes. The mass curves and the flow duration curves will give us the firm power that could be had, the quality of storage that could be effected and the size of the development and how best the plant could operate in conjunction with steam plants.

Other notable advancements that have taken place in the field of hydrology are the methods of accurate and automatic recording of rainfall by the use of radio and radar net works in the basin. In the T. V. A. area in U. S. A. there are a number of radio operated and radar operated rain gauge stations, so that the information regarding the intensity and duration of the rainfall is recieved at a central stations so that instructions could be flashed to various dams and control works for proper regulation and operation of reservoirs so that flood hazards are minimised and no water wasted.

Determination of the maximum flood at a given point on the river and the frequency of floods is a very important factor. The good old methods of ascertaining the flood levels and the utilization of several emperical formula have been replaced by the unit Hydrograph methods and the statistical methods of analysis of flood frequency. This has enabled the engineer to design the spillways in a more scientific manner and also facilitate the regulation and operation of multipurpose and river valley projects. Even in the absence of data for the given basin, available data of the adjoining basins are made use of to arrive at a reasonably accurate analysis of rainfall, run off and flood flows. Adoption of these methods save a lot of time and money in the investigation of hydroelectric projects.

Another notable advance made is the aerial photographic survey. The development of aerial photographic survey and the technique of drawing contours by stereoscopic methods have saved the engineer from a lot of worry and anxiety. Normally a topographic investigation of a hydro power site when conducted in great detail may require 3-4 years or even more for a thorough investigation. All this could be avoided. The taking of aerial photographs in the area concerned is a matter of a couple of days and a few months are needed for collecting and establishing some ground control points and the remaining work is entirely computation and office work. This latest development effects considerable savings in time and money and the accuracy of the work is also fairly high. It is absolutely essential to carry out all preliminary surveys for the water spread of the dam, the sites for station, water conductor systems, roads and communications and transmission lines to be investigated thoroughly by aerial surveys.

Even with regard to ground investigations, a lot of improvements have taken place. The old method of cutting open trenches and trial pits at sites where the hydraulic works have to be built is becomming obsolete. This old method involves time and labour. The latest methods of boring, the geophysical methods, and the utilization of drifts and tunnels are gradually replacing the old trial pits and trenches. Deep bores running down to hundreds of feet could be driven in earth and samples of strata through which the bore has passed are collected and examined. By a judicious distribution of bore holes, supplemented by geophysical studies and surface studies, very accurate data of the soil and rock at dam site, tunnels, power station site, etc., could be established without much waste of time and money. The adoption of inclined shafts, drifts and large diameter bore holes enable a comprehensive study and visual examination of soil and rock and formulate proper proposals for construction and treatment.

Dams and Control Works

Very rarely a basin could be developed fully for the development of water power without a proper storage reservoir. Gravity dam which was based on the middle third rule, which is still popular in dam construction has undergone a lot of improvement in the design methods, construction methods and operation methods. The gravity dam has now been used for more than 700 ft. height. The arch gravity dam at Boulder is 728 ft. high. The Bhakra dam in our country is 680 ft. and is the world's second highest am. It incorporates the latest developments in the design procedure, testing methods, better materials available for construction and the utilization of most modern equipment that are responsible for the use of gravity dams for great heights. Notable advances are also made in the use of arch dams, rock fill dams, earthen dams and buttress dams. In regard to arch dams there is a tendency both to increase the height and crest length. The crest length of Hungry Horse dam is 2130 ft. The maximum height of arch dam built is 745 ft. in Switzerland. The above indicates a very bold advancement in arch dam design and construction. These bold developments in the masonry dams are entirely due to improvements in the

design procedure. The trial load analysis to determine the stresses and deflection in dams is the best known analytical method to determine the stability of dams. The development of experimental techniques like the photoelastic methods, the various analogues viz., the slab analogy, the rubber analogy and the Brittle Coat methods enable the designer to determine the points of stress concentration under different conditions The use of strain gauges and the strain analysers enable to determine the stresses at different parts of dam under different conditions. The perfected and refined design methods is not enough. There is parallel development in the materials of construction techniques like the design mix, control of water cement ratio, the cooling of concrete, proper placing of concrete, accelerated curing and so on that has enabled the engineer to build dams of any height. The cooling of concrete in the dam construction is a very important factor. Miles and miles length of copper tubes through which cold water is circulated, has been embedded in Hoover dam on the Colorado river and the heat of cement is taken away so that cracks are not developed in the masonry. In the construction of some dams, precooled concrete is used. The aggregates are cooled to a predetermined temperature before the concrete is mixed and laid. This method is adopted in Vaitarna dam for the Bombay city water supply. The vibrating of concrete and accelerated curing of concrete are also extensively used to obtain rapid progress in the construction of dams with increased structural stability by preventing formation of cracks due to temperature etc.

Another development in the construction of dams is the embedding of different instruments to study the behaviour of dam after construction due to various forces of nature, like earthquakes, settlement in founda tion etc., and also how the materials behave after construction. The data so collected are very useful for the design and construction of dams in future. With this in view all modern dams are provided in them resistance thermometers, strain meters, joint meters, hydrostatic pressure gauges, tiltmeters, piezometers, seismographs embedded in them. Systematic data collected on these instruments will be very useful for the design and construction of dams in future.

The latest methods of foundation treatment like grouting under high pressures, provision of deep cut-off, drainage galleries, grouting galleries and long blankets both up and downstream has made the construction dams feasible on any type of foundation. The various dams on the Wisconsin river in U.S.A. and the Imperial dam on the Colorado river from which the great All American canal takes off has been built on sand. Even in our country a number of hydraulic structres particularly in Punjab, have been built on pervious foundations and Shri Khosla's theory of Foundations on permeable soils is one of the accepted theories in present-day engineering practice.

Even with regard to the earth fill and rock fill dams and elimination of core walls, which is replaced by zonal construction are entirely due to the recent advances made in the soil science and the scientific utilization of the materaials employed in the construction. The Mohr's method of analyzing the slip in earthen dams has added strength in their design. Very high earthen dams are built now-a-days, the maximum height being 360 ft. The use of earthen dams is not entirely due to the development in soil science and scientific approach for the selection and utilization of the material. But for the advent of heavy handling machinery like the bulldozers, the scraper, the dumpers the graders and the heavy duty rollers, earthen dams would not have come up to the levels and standards at which it stands to day. Huge projects of earthen bunds have been completed in record time with perfect structural stability.

The present-day tendency is to build big dams, impound all available supply of water, make use of biggest machines for the generation of power. In addition to building dams we should have proper outlet structures to take the water from the reservoir to the machines. These require very big intake structures and gates and valves to control the water flow. Further large quantities of water will have to be surplussed during floods when the dam is full. This has necessitated the adoption of very big control structures and gates. Here in the design of efficient control structures, the electrical analogy methods and analytical methods are very helpful to find out the best shape for the vents and approach. The photoelastic method of analysis will enable stress distribution and concentation at the openings and round about the openings in dams. With the increase in the capacity of the units, large quantities of water will have to be handled. The present day design of gates is more for making the gates reliable in operation and minimum maintenance. Model studies of gates have contributed in no small measure for the development of gates. The reliability of power plant depend on the rates. The cylinder gates, the needle valves, the butterfly valves, the spherical valves and caterpillar gates are the several gates that are in use, working under high heads, handling very large quantities of water. Roller and slidegates have been considerably improved. Very large sizes are operating under very high heads. Butterfly valves, needle valves, spherical and conical type of valves have been developed considerably and are used for very high heads in place of needle valves and butterfly valves.

Spillway gates have increased in size enormously handling very large quantities of water. In this field more reliable operation with minimum maintenance are the guiding features than the ingenuity in design. Crest gates of $50' \times 50'$ are used to dispose the floods at Parker and Davis dams on the Colorado river. Drum gates which are automatic in action (Fig. 1) 100 ft. long and 16 ft. high each one of them weighing as much as 5,00,000 pounds are used at Boulder dam. The advantages of the drum gates are: (1) In the lowered position the top surface of the datesprovides a curved surface conforming to the profile of the weir crest, (2) The water flows over the gate affording an unobstructed water passage and because the curved surface of the lowered gate forms the spillway crest, improving the hydraulic properties of the spillway. These drum gates are installed at Norris dam, Grand Coulee, the Shasta and other dams. At Grand Coulee the size of the drum gates are 135 ft. long by 28 ft. high.

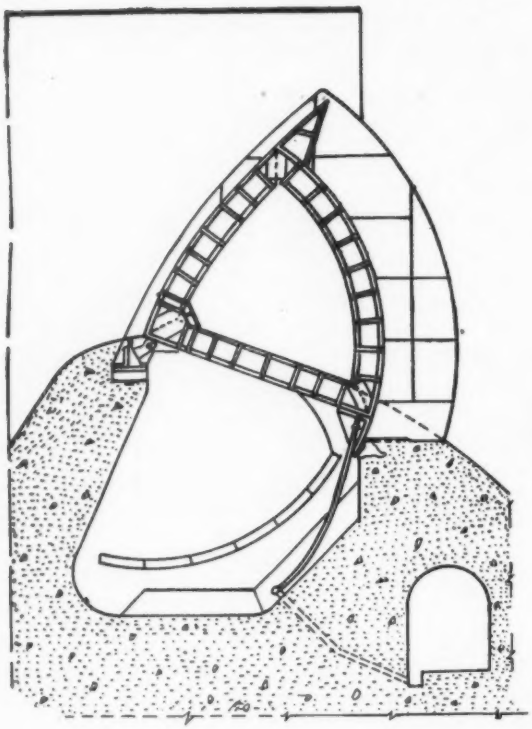

FIG. 1
DRUM GATE

The other very common type of spillway gate used for flood disposal are the Roller gates. These are very suitable for controlling discharges at low head dams where unobstructed passage ways between the piers are desired to permit passage of ice and floating debris. Four roller gates of 75 ft. × 22 ft. are used at the Imperial dam on the Colorado river. (Fig. 2).

The tainter gates and the segmental gates are extensively used. These gates are designed for open channel flow and big sizes of as much as 50 ft. × 34.5 ft. high has been used.

The above mentioned and many other types of gates viz., the Stoney gate, Caterpillar gate, Ring gate, Cylindrical gates are extensively used.

Another development is the use of Roller weirs developed by M. A. N. Germany where very big size weirs are manufactured. Some of them are 130 ft. long for a head of water of about 25ft. The advantages of the roller weirs are that they are robust in construction and simple in operation. The design enables weirs of large clear widths to be built having the drive operated from one side only. It is very effective in offering resistance to ice and sedimentary material carried along the bed of the water course. From the hydraulic point of view it has the most desirable form of over

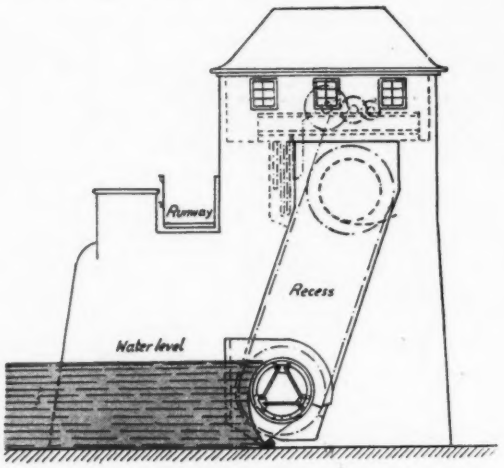

FIG. 2.
SECTION OF A ROLLER WEIR WITH DRIVE PIER

flow and the longest service life due to the absence of any critical moving parts (Ref. Fig. 2 a to 2c).

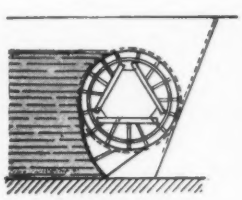

FIG. 2 a
ROLLER WITH APRON ATTACHMENT

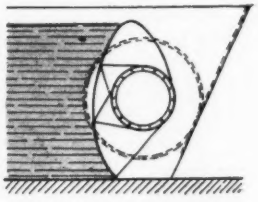

FIG. 2 b
ROLLER WITH COMBINED TOP AND BOTTOM APRON

Energy Dissipators

With the construction of very high dams and large quantities of water to be handled, the question of energy dissipation of the waters falling from the top of the dam to the river bed below is a very serious problem. If left as such the bed will be scoured and retrogression of levels may endanger the structure itself. Various forms of energy dissipators are evolved.

The water issuing out of gates, sluices and valves also has enormous energy in it and it has to be dissipated by some method. The main function of the energy dissipator is to reduce the velocity in some form or other. This can be achieved by (1) creating a hydraulic jump and impinging the falling waters into the jump. (2) by the use of friction blocks of masonry or concrete. The use of the blocks reduce the length of the apron. (3) providing a stilling basin (4) use of ski jump (5) upturned buckets (6) impact of one jet with another (7) dispersing the jet by giving a rotary motion for the flow (8) by entraining air in the flowing water and increasing the depth of flow with consequent reduction in velocity.

The most effective and common energy dissipator is the upturned bucket. For all tail water conditions,

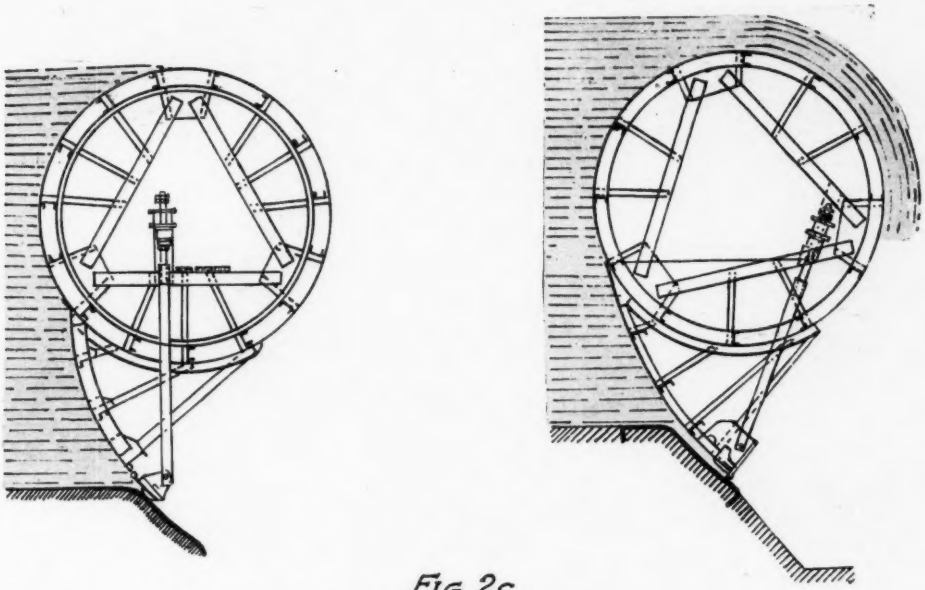

FIG. 2c
SUBMERSIBLE ROLLERS
WITH SPRING LOADED SEALING JOINTS

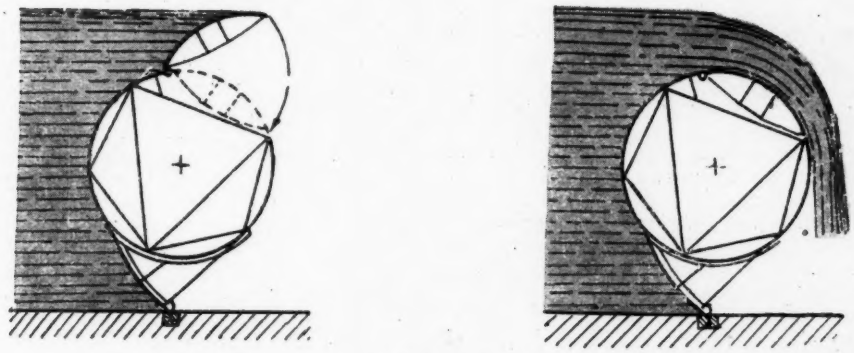

FIG. 2d
ROLLERS WITH FLAP ATTACHED
CYLINDER WITH FISH BELLEY SHAPED FLAP

the jet is thrown out of bucket and forms a piling vortex. The bucket may be semicircular or may have a slope of 45°. The design should be such that the positive vortex formed should pile up the scoured material at the toe of the bucket.

The ski jump spillways are quite common in France. Some times pairs of ski jumps are so oriented that flow of one impacts on the other so that a lot of air gets entrained in water with consequent reduction in velocity.

In the case of tunnel outlets when they are used to dispose the flood waters the jet is deflected by using shapes similar to the turbine buckets at the end of the conduit. The geometrical shape given is such that the flow is given a whirl before it leaves the conduit so that most of it fan out into apray. This type of construction is to be seen in the Fontana dam tunnel spillway of the T. V. A.

In the outlet pipes at the Hoover dam jet deflectors are provided at the end of the penstock pipe and this gives a rotary motion and the flow spreads and gets entrained with air and drops down with minimum energy.

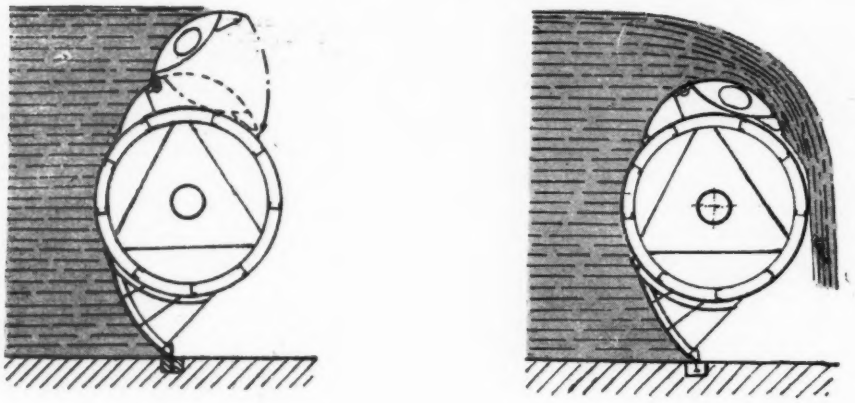

FIG. 2 e
ROLLERS WITH EXTERNALLY ATTACHED FISH BELLEY FLAP

The Water Conductor System

This may be open channel, flumes, tunnels and penstocks or any combinations of the several units.

Under channels a lot of improvement has taken place in the canal linings which tend to reduce the cost of the linings. The various types of lining used are the stone revetment, brick lining, sandwitch lining, concrete lining and so on.

Factors that have reduced the cost of lining are:

(1) use of modern machinery in the preparation and placing of concrete (2) eliminating reinforcement, savings of 10 to 15% cost (3) use of sub-grade guide slip forms (4) standardisation of canal shapes and sizes (5) buried asphalt membrane lining has been developed which consists of hot sprayed-in-place asphalt cement covered with a protective blanket of earth or gravel; (6) use of prefabricated strips of asphalt membrane lining (7) adoption of large earthmoving equipment. This has facilitated greater use of thick compacted lining of selected earth, (8) devices and test procedures for measurement of seepage losses, so that required data could be obtained to assure maximum effectiveness from a minimum of lining.

The latest linings used are:

(1) *The shot-crete lining*—This consists of mortar of selected sand Portland cement and water applied to canal subgrade by means of a jet This can be used in any area, any shape and may be used for irregular sub-grades. This is specially useful for repairing hard surface linings. (2) *Asphalt lining*—Asphalt concrete and buried asphalt membrane are being used of late. In the former a mixture of asphalt-cement and selected aggregate are mixed hot and placed by mechanical equipment. This is cheaper than Portland cement concrete. In the latter a thin layer of asphalt is sprayed in place at high temperature and covered with twelve inches layer of earth material for protection. (3) A prefabricated asphalt membrane is being developed that eliminates the need for special equipment. These are delivered in rolls and laid directly on the subgrade and covered with earth or gravel. (4) Where good earth is available it can be used with advantage. The earth is laid in layers of 6″ to 8″ and 6 to 8 ft. wide and compacted by sheep foot rollers. (5) Bentonite which is clay type soil which swells when wetted is used for earth linings. This may be mixed with natural subgrade soil and laid and compacted. Bentonite could be used as a membrane directly on the subgrade. (6) Soil-cement which is a mixture of cement and natural subgrade soil and water is mixed in place, laid and compacted by rolling. (7) *Shot-crete lining over asphalt membrane*—Thin covers of shot crete over an asphalt membrane is used. This lining being relatively thin is very useful for lining rock cuts and prevent seepage. (8) Synthetic plastic lining is still in an experimental stage. They are very light and can be had in very thin sheets and the success of this depend upon a suitable cover to hold the sheet in place.

Underground Penstocks: Tunnel is being extensively used to convey water to the machines and avoiding large number of long steel penstocks. The modern method of tunnelling has practically no limitations. Tunnels could be driven in any type of soil and rock. The modern equipment and techniques have so much advanced that tunnelling is preferred. Now there is a growing tendency to build underground hydroplants and there is wide application for pressure tunnels. Especially in France, Switzerland, Norway and Sweden pressure tunnels are extensively used. There is a growing tendency to install penstocks underground much more frequently than formerly was the case. This is done for the reasons that have made necessary for the adoption of underground power houses,

to afford protection of the site, military protection, or where to pographic conditions make it necessary, but more often for reasons of economy in metal and funds. The progress in technique is rendering such underground installations more favourable and feasible and safer each day. The construction procedures have been perfected. The cost of underground excavations has decreased considerably and also the delays and risks involved in tunnel driving.

An underground penstock consists specifically of a steel lining embedded in concrete in a rock excavation. In the oldest and widely used tunnels, the lining was the principal element of strength. This type has often been regarded as a transposition of an overground penstock that has merely been adopted to a certain extent to its undeground location. A frequent transition between the lined underground tunnel and the ordinary penstock is the penstock placed in a tunnel, which requires the rock merely to afford a more direct passage or a protection against rolling boulders, avalanches.

A thick conduit back filled in rock is usually designed as a free pipe with a higher rate of fatigue for the metal. In most cases it is necessary to prevent the occurrence of stresses equal to or exceeding the elastic limit of the sheet metal. Rock and concrete are only to provide additional strength.

The resistance to linings for taking external pressures and uplift was not sufficiently well known to permit reducing the thickness of steel plates. It was also feared that leakages might feed to natural ground water and increase in pressure. In order to relieve the pressure, drains were provided in the backfill portion around the penstocks. These drains lead to large increases in stress in the concrete lining. Drainage galleries are very expensive structures and the division of discharges from underground penstocks is a very difficult proposition but the latest method of welding technique has made it possible to weld 4" thick plates very satisfactorily standing very high pressure. Use of such welded construction has avoided the drainage problem in underground penstocks.

Of the recent advances made to make the underground penstocks water tight is by sealing the back fill concrete by injection of grout. This method permits the elimination of drainage galleries. This grouting also increases the resistance of the pipe to buckling. This method of construction eliminates almost entirely the spaces at the contacts of the various materials. It represents a first application of placing the lining and the concrete in compression in advance. If grouting is done properly, it would be possible to subject the rock to the maximum loading that it is capable of taking and consequently the lining could be tightened considerably.

As early as 1925 Marinoni in Italy with the unusual boldness undertook the construction of underground penstocks for very high heads as much as 2500 ft. He used flexible linings hardly 0.16" thick. Some of the injuries observed in the penstocks was entirely due to uplift pressures. Experience with numerous penstocks of the Marinoni type proves that linings are not indispenseble for its stability.

Concerete Linings

It has been found that concrete having a controlled granular composition remains quite water tight at high heads, so long as its compression exceeds the hydraulic pressure. There is a limit to the pressures that concrete linings can sustain. It is found difficult exceed a head of 656 ft. prestressing of concrete to the underground penstock, where sealing of concrete could be achieved by tension prestressing of reinforcements. This prestressing of concrete has been extensively used in France and Italy. Prestressing could be done by grouting into the annular space.

Ordinary reinforced concrete also could be used. Such concrete cannot sustain tension in excess of about 425 psi without cracking, hence without losing its water tightness in unsound terrain as such the use of reinforced concrete lining should be limited to low pressure conduits in sound rock. The R.C.C. penstocks have been used and are standing quite well. Concrete linings are practically unaffected by uplift.

Lining can completely be eliminated in indecomposable rock and when the rock is sufficiently water tight. Elimination of lining was accepted in Norway as early as 1920 for heads upto 500 ft. It was contemplated to unline the tunnel of Canon del Pato in Peru with a head of 1400 ft. but the rock was found to be traversed with cracks. Hence light lining was provided.

Hence it could be seen that the underground penstocks are not necessarily metallic conduits encased in concrete. The three constituent materials of underground penstock are steel, concrete and rock and depending upon the characteristics of the rock met with the use of either of the materials lining will have to be decided.

Condition for the Construction of Underground Penstocks

In the designing of an underground penstock, the geologist plays a very important role. The position of the penstock in the mass should be such that the covering amply exceeds 40 to 50% of the operating pressure of water in the penstock. The slope of the penstock depends upon the topography and the method of excavation planned either from top or bottom. Generally an angle of 40°. The diameter of the tunnel depend mostly on economic considerations and energy losses. It is always advisable to merge two or more conduits into one and this will decrease the losses and reduce the intensity of water hammer. The excavation for the tunnel should be done very carefully and the main heading should be done by closely spaced borings and using moderate explosive charges.

The lining of penstock tunnels is a very important factor. It is always expedient not to leave the rock bare and without support, till lining is put in. It is always better to give a preliminary lining of plain concrete closely following the tunnel heading. Where the tunnel encounters a faulted zone, it is always

preferable to build a thick ring of R. C. C. at the periphery of the excavation. Such a ring is preferable to an increase in the thickness of the metal lining.

Lining is invariably done for all pressure tunnels where the static pressure exceeds 540 ft. For heads less than 500 ft. R. C. C. lining could be used. For heads upto 800 ft. prestressed concrete could be used without any metallic lining. For higher pressures and for ensuring water tightness metallic lining is absolutely essential.

Design of underground penstocks is a very interesting one as we have to deal with three different type of materials viz., rock, concrete and steel whose elastic behaviour is not the same and the elasticity of the rock depends upon various considerations. Elasticity of the rock is not everything. The strength of the mass should be sufficient. The natural compression of the mass is an important factor. Theoretically an underground penstock can support a water pressure equal to the minimum compression observed at its walls. No tensile stresses should be allowed in the rock behind the metal lining and if tensile stress exists it should be supported by grouting. In order to take the thermal shrinkage into account some additional compressive stress (about 350 psi) is allowed in the rock and concrete and about 40 psi of tension allowed in sheet metal of the lining.

Sealing the rock is an additional safety factor. Thorough injections of grout should be provided for filling and sealing at the contacts between concrete and the rock and between steel and concrete.

Underground power houses are mostly accompained by underground penstocks. The passage of a deep lying tunnel to the surface is a very delicate problem. Ample rock covering is the only safety measure not only to the power house but also to the penstock.

A properly constructed underground penstock should provide almost total safety. The only operational difficulty in penstocks back filled with concrete are the development of cracks and this is no grave consequence. If the penstock includes a drainage system, a lot of damage can be expected due to rupture at the drainage gallery control gates or at the surface and in that case considerable damage could be avoided by providing gates. It may be preferable to isolate the foot gates in a separate gallery or in separate chambers or to reinforce the drainage galleries than to protect the penstocks by means of head gates.

Experience in the underground penstocks have revealed that it is always preferable to eliminate all causes of dissymetry at the circumference of the tunnel and particularly the drainage galleries. The tunnel through decayed rock should receive a thicker and more uniform refill, reinforced if necessary. The perfect water tightness should be sought so that the rock will remain in good condition. The safety of the underground penstock should be listed on the finished structure. Water tightness test is the first and each joint should be tested. The localised leaks should be a minimum and the diffused leaks should remain well below the normal drainage of the rock. The second test to be performed is the pressure test. It is not possible to put higher pressures than what it is designed for. It is preferable to prolong the duration of the load and to verify the stability of the deformation with respect to time. We can easily measure the total leakages and the elastic swelling in the penstocks.

In the above paragraphs the techniques involved in underground penstocks has been briefly explained. The adoption of underground stations which will be explained in detail later has given a lot of fillip to underground penstock and pressure tunnels construction. It is the modern method of tunnelling which is responsible for the successful use of underground penstocks, pressure tunnels and underground power stations. The latest developments in tunnelling technique will be given below.

Tunnelling Technique

Extensive developments in the tunnelling technique is mainly responsible for the successful construction and operation of underground penstocks and underground power stations. The modern technique allow tunnels to be driven in any type of strata, be it rock or soil, under water or in dry and strata.

The progress consists mainly in extensive mechanisation of the drilling and removal of the spoil and in the use of high speed drilling equipment, resulting in rapid progress and lower cost per c. ft. of excavation. Considerable progress has been achieved in dealing with difficult rock conditions. The methods for concrete lining the tunnels have also been considerably improved. High speed drils with tungsten carbide and coablt tipped cutters are extensively used. The drills have fixed bits and are sharpened with carborundum discs near the place of operation itself which saves considerable time and money. The American Jurbo where a number of drills could be operated from platforms are extensively used. This permit the use of a large number of drills. An average of 22 holes or more of 8 ft. deep could be drilled per round with a heading of $8\frac{1}{2}' \times 8\frac{1}{2}'$.

Advent of automatic drills which stop at a set distance automatically, wash out the hole, retract the drill bit has considerably reduced the labour charges and one driller can operate 2 or more drills simulataneously. Another reason for the success of the underground penstock and tunnel is the mechanised handling of muck and spoil from the tunnel. The rapid handling equipment like the loaders, dumps. jigs shovels, tractors tip wagons, diesel locos and cranes have made the removal of spoil a simple affair. No time is wasted and work will go on unhindered. The drills are mounted on air legs and this affords a very considerable advantage. The heavy duty rills of Ingersoll Rand of U. S. A. and the Swedish light drills (Atlas Diesal or Atlas Cooco) are very efficient. The life of each drill bit is about 80 ft. with dressing after every round of 40 ft.

After blasting the smoke in the tunnel is removed by using fans. Very good ventilation is secured and all the foul air could be removed quickly so that mucking operation could start immediately after blasting with little waste of time. The upper holes of the succeeding

round could be drilled from the muck pile while load ing of the broken rock at a distance from the face had started. All these go to expedite the progress of tunnelling.

The "roof bolting" has proved a very successful method for tunnelling in medoicre rock. In this method large pieces of rock are anchored with prestressed cables and held in position.

In addition to the developments in modern machinery, tremendous advances have been made in actual tunnelling. In case of wide tunnels, the lower half is first excavated along the entire length and the rock spoil is used as scaffolding for the drills on the lower half. For tunnels with large areas of section a small tunnel is generally driven at the level of the access tunnel and shafts are then driven to the roof levels where one or more longitudinal tunnels are made from which the upper part of the tunnel is tackled. Concrete lining is put on the top for the roof and then the lower portions excavated working from the shafts.

Another method adopted is to drive four headings at the four corners of the cross section and the rock between the top headings are removed, to the required arch shape. Then concrete is put to the arch of the roof, using rock below as the working platform. Then the headings at top and bottom of each side wall are connected by a vertical slot. Then the main rock prism is removed and the concrete facing of the side well placed.

In India a large number of tunnels are driven and there is no dearth for men trained for this job The 50 ft. dia. tunnels of the Bhakra Nangal Project, the railway tunnels in the Bhor and the Tall ghats of the Central Railway and the tunnels interconnecting the Tata lakes of the Hydro system and the tunnels of UHL river scheme and the tunnels connecting the Tansa lake and the Vaitarna lake of the Bombay water supply system are standing examples. With this experience one should have least doubts and should not hesitate to adopt underground penstocks and under ground power plants in our country. Remarkable progress ' in tunnelling could be appreciated from the progress of 557 ft. made in seven working days in one of the tunnels in England.

Steel Penstocks

Rapid advances and developments have taken place in the design and manufacture of penstocks also. The time-old rivetted penstocks have been replaced by welded pipes. The welding technique has been so perfected that a welded joint is stronger than the material itself. The quality of steel has also improved. Welded joints in penstocks of even 4" thick have become common. For very high heads the use of banded pipes and seamless tubes have aleady been used. These bands reduce the thickness of the pipes and handling will become a very easy affair. A.S.T.M designation A 285 Grade C steel with a minimum tensile strength of 55000 lbs/sq. in. and with a minimum yield point of 30,000 lbs/sq. in and A212 crade B steel of minimum tensile strength of 70,000/sq. in. and a minimum yield point of 35,000 lbs/sq. in. are extensively used. In order to take care of expansion of the pipe due to variations in temperature, rockers are being installed at the supports in addition to expansion joints.

All welded penstocks are stress relieved before they are tested after a complete radiographic inspection. The stress relieving is done at temperatures ranging from 1100 to 1200°F for a period of 1 hr. per inch of maximum plate thickness in pipe section. The cooling is done gradually. After the pipes are stress relieved each pipe section is subjected to a hydrostatic pressure test. Test pressure of 1½ times the designed pressure is applied to produce the desired stress of 20 to 26000 lbs/sq. in. depending upon the type of steel used.

The latest development in the design of penstocks is the prestressed pipes and the multilayer penstocks. This has been developed by A. O. Smith Corporation, Milwaukee, Wisconsin U. S. A. A savings upto about 15% in weight of steel required for conventional single wall penstocks could be obtained. These penstocks consist of thin layers of plate steel of high tensile strength, each layer progressively wrapped around an inner core tightened and welded to form a lighter and stronger penstock. In tnis method the costly stress relieving of welds are eliminated and it is claimed that these pipes could be used for any pressures.

Recent Developments in Hydraulic Machines

A very elaborate paper has been published by Prof N. S. Govinda Rao and K. Seetharamiah on the "Modern Trends in Hydraulic Turbine Practice". In this article the modern developments of hydraulic turbines will be indicated in brief.

There is a growing tendency to build more and more hydro stations, utilize the full quantity of the water available in the basins economically and interconnect the power plants. The interconnection of the plants has enabled the use of very large capacity units and avoidance of spare units.

The adoption of large size units is dictated by considerations of economy. This reduces the number of units, the total cost of which may be cheaper than the corresponding number of smaller units for the same power output. Smaller number of units reduce the cost of the power house building, penstocks, generators and ultimately save maintenance and operation costs. The interconnection of the plants assures continuity of service even in case of breakdown and this has helped in the elimination of spare units and installation of big size units. This is the trend not only with hydraulic power but also steam driven machines. Allis Chalmers are building a 500,000 H. P. steam turbine and alternator for some plant in U.S.A. Blue prints for a 10,00,000 H. P. alternator for a steam power plant are under way at Allis Chalmers. With regard to the water turbines there appears to be no limitation in the capacity. The biggest Francis turbine is 154, 000 H.P. built by Charmillis, Switzerland. The worlds most powerful Kaplan turbine is 111,300 H. P. working under a head of 80 ft. The biggest Impulse turbine built is 140,000 H. P. for the Aluminum Company of

Canada working under a head of 2485 ft. River in Italy has built a doubt runner impulse turbine of 150,000 H. P. The 66000 H. P. capacity Kaplan type runner of 23′ 4″ dia. which pass a discharge of 13000 c. ft, are installed at Bonnville dam in U. S. A. Thus it could be seen that there is a growing tendency for the adoption of bigger and bigger units.

At one time it was felt that the Kaplan turbines could be used upto about 100 ft head, the Francis turbine upto about 800 ft. head and above that the Impulse Wheels. With the developments in the materials used for construction and the improvements in design it appears as though there will not any limitation as above mentioned. Impulse Wheels are built for heads more that five thousand feet and Francis turbine whose domain was formerly limited to about 600 ft. has encroached to the domain of Impulse Wheels. There is a fast growing tendency to use Francis wheels for high heads. At some installations in Norway Francis turbines are used for head upto 1500 ft, In the field for the use of propeller turbines formerly the head was limited to about 100 ft. Now there are some installations where the head has gone upto about 230 ft. and there is a growing tendency to use Kaplan turbine for higher heads. There is no limitation for the use of Impulse turbine for any head and any capacity. It is the manufacture details and abnormaly high stresses that come on the machines that has now become the limiting factor. Single jet Impulse runners are improved to vertical type multiple jet machines which consequently increases the capacity of the unit.

In India we are not backward in using the multiple jet multiple runners. The 18000 H.P. units of Mahatma Gandhi Power Station at Jog have double runner double jet. The proposed machines for the Sharavati Valley Project with head of about 1500 ft. is the high head Francis turbines. The Koyna project of Bombay are contemplating to have Impulse units of 60,000 H.P. in their proposed underground station and it is quite possible that high head Francis units may be more favourable.

There is a growing tendency in the use of high specific speeds for the water turbines. The advantage of using high specific speeds is that the size of the alternator gets considerably reduced and this results in savings of cost.

Cavitation of Turbine Runners

With the use of machines of high specific speeds the cavitation problem is a very serious one particularly with reaction turbines. Due to the high velocities with which the water moves in the turbine runner, cavitation occurs at points of lower pressure and if this is left unchecked will ultimately eat away the runner blades. The cavitation parameter for the turbine is given by $\frac{H_b - H_a - H_v}{H}$

where

H_b = Barometric pressure
H_a = Suction head on bottom of the turbine runner in ft. of water
H = Net operating head of the turbine
H_v = Vapour pressure of water

We have to consider the runner cavitation sigma and the plant sigma. The lower the sigma value the higher the runner can be set with reference to tail water.

The increase in the specific speed of the machines result in high discharge velocities with consequent cavitation. It is established that:

(1) All turbrne runners will cavitate when set high above the tail water

(2) Cavitation can be reduced by increasing the pressures which mean the setting of the turbine very low but this is not always feasible and even if feasible may not be economical.

(3) The velocity can be reduced but this results in bigger size, which mean greater cost for the machine as well as of the power station.

The present day tendency is to increase the size of the turbines, allow higher and higher velocities and set the turbine as high as possible to reduce the excavation and foundation costs. A lot of improvements have taken place all over the world in the materials used for the construction and also construction techniques. Notable advances are made in the use of welded construction. Most European manufacturers still make a liberal use of cast iron and cast steel. These materials are heavier than fabricated steel but being rigid they are favoured. But welded construction is growing rapidly. Practically rivetted construction is going out of date. The scroll case, the top and bottom covers, the guides, the stay rings, the draft tubes are all of welded construction. With regard to the manufacture of runners stainless steel is rapidly gaining ground. But stainless steel is costly. Hence use of stainless overlays in strips or welding stainless steel at points where cavitation is likely to occur. Another notable advance made is the casting of runners particularly the Francis runners is 2 or 3 pieces and after machining and finishing they could be bolted together to form one unit. M/s. Allis Chalmers had made one runner of Hiwassee pump turbine in 3 pieces to facilitate transport. The diameter of the impeller is 15 ft. and weighs 132 tons. As a turbine it develops 95,000 H. P. and as a pump gives a discharge of 4000 c.f.s. against a head of 300 ft. and consumes 100,000 H.P.

With regard to the Pelton turbines, the use of bolted buckets is getting out of date. Integral castings of buckets and discs is the order of the day. Stainless steel is extensively used these days in Hydraulic machinery manufacture. In Europe 12 to 14% chromium steel is extensively used. Stainless steel has got the supreme quality of resisting erosion and at the same time it is easier to machine and less liable to siezure. The inlaying of stainless steel is very easy and in case of turbine runners, at points where cavitation is expected stainless welding is done. Even when the water carries excessive abrasive material, stainless steel stands the abrasive action well. The use of stainless steel increases the period between consecutive overhauls of the turbines and also reduces the number of outages. For greater heads, beyond 600-700 ft. it is advantageous to use stainless steel wicket gates, stay rings, wearing rings etc.

In addition to the damage of the runners due to cavitation care has to be taken against damage due to errosion, on account of the presence of sand, grit etc. Even stainless steel which has a high resistance to pitting does not have resistance to erosion. Even 12—14 chromium steel is better than 18—8 chrome nickel stainless steel. Aluminum bronze called the Amco Bronze has very good resistance to erosion. This special alloy has got both the resistence to cavitation damage and erosion and it has a very promising future but the only disadvantage is that it cannot be welded overlaid and the runner will have to be removed for repairs. The high resistance of the metal both for pitting and erosion promises the possible use in the manufacture of hydraulic equipment. Other notable advances made in the hydrablic turbine and other accessories are:

(1) Development of adjustable pitch Francis turbine

(2) The isolating shutter gear for Hydraulic turbines

(3) Seewar governing system for Impulse water turbines

(4) The midget hydro units

(5) The tubular turbine

(6) The reverse pump turbines.

(7) The development of cabinet type of governor

Adjustable pitch Francis Turbine

This is otherwise called the English Electric Deriaz type or Feathering Francis turbine. The ordinary Francis turbine has good efficiencies at or near full load but falls off rapidly above and below the optimum load and also for heads below and above normal. This draw back has been overcome by arranging the runner vanes on a slant and feathering, so that the angles, being rigid can be adjusted to conform with the changing load and head. The performance of such runners is found to be better than the Kaplan turbine and this renders it possible the use of the feathering vanes for heads much in excess of the ones now in use for Kaplan runners. The range of efficiency of this type of machine is broadened for very wide variations in output and head. The adjustment of the vane angle is brought about by the automatic governor and obviates the danger of vibration and cavitation.

The Feathering Francis turpine is admirably suited for working both as a turbine as well as a pump in the reverse direction. English Electric Company have orders for the manufacture of 6 such units of each 53,500 H.P. output each for the pump storage plants of the Niagara Power plant. It has been found that these machines at less than one third the normal design head has efficiencies of 65 to 70%. This enables large quantities of units to be produced long before completion of the dams. The adoption of this kind of units will allow production of electrical power far in advance of the completion which in large projects may take several years.

Isolating Shutter gear for Hydraulic Turbines

This is also the development of English Electric Company England. The principle features of this are:

(1) It replaces the main stop valves at Turbine entrance

(2) Seals automatically when closed

(3) Reduces the size of the power house

(4) Permits by passing of water through turbine calling without installing seperate penstocks.

One of the important tasks in the design of hydroplants is for the establishment of a proper isolating device which will permit the turbine to be isolated from the penstock for inspection, dismantling and maintenance. Normally a stop valve may be a sluice, butterfly valve or rotary valve. These are always heavy and occupy cosiderable amount of space and involve a lot of money. The maintenance of the valves is a very serious point and has to be made accessible to the crane and this involves in a lot of space. A stop valve in front of a turbine isolates the runner wheel distributing apparatus and the spiral casing. The spiral casing which is after all the tail end of the pentock do not need much maintenance and if the device is just capable of cutting off the water from the runner and distributing system, it will serve the purpose. This requirement is met with by the adoption of the Isolating shutter gear. (Fig. 3) This gear utilises a

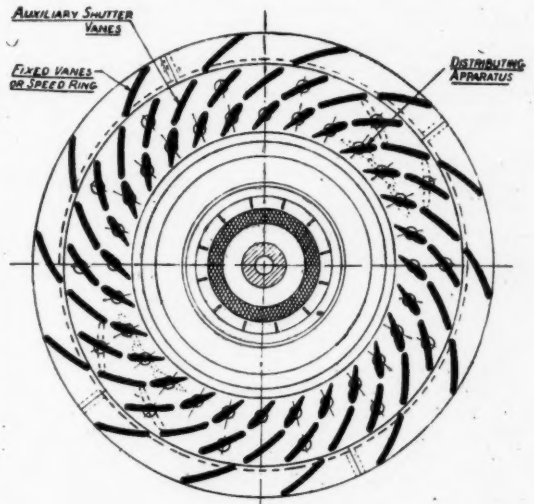

FIG. 3
ISOLATING SHUTTER GEAR

number of streamlined auxilliary swivel vanes arranged with in the speedring of the turbine and in front the distributing apparatus. When the shutter vanes are rotated to closure, the distributing apparatus, the runner wheel and all other part are isolated from were in the penstock.

The auxilliary swivel vanes, when open enhance the correctness of the intake vortex to the turbine runner. When closed they over the space between the two adjacent fixed stay vanes thus forming a complete

isolating ring which separates the water from the inner turbine space.

The design of the auxilliary shutter vane is similar to the guide vanes. The sealing of the vanes when closed is brought about by insertion of rubber strips bolted on to the vane and at top and bottom of the speed ring. The shafts of the auxilliary shutter strongly held and guided in three bronzed bushed bearings can all be lubricated from the top of the turbine cover. The auxilliary shutters are closed by oil pressure servo mechanism and a hand operated safety gear is also provided.

In plants where continuous bye passing of water is required as in irrigation schemes, the turbines are provided with bye pass valves. The use of the isolating shutters allow the inspection and dismantling of the runner and the flow out of the penstock through a bye pass valve will go uninterrupted. By the adoption of this seperate feeder pipes and intake gears could be avoided. These gears are incorporated in the propeller turbine of 19,200 B. H. P. of the Khatima Hydro Electric plant in India. Two 39,200 B. H. P. with auxilliary shutter device are installed at the Hurve Reservoir Plant in Australia.

Seewer Governing System for Impulse Turbines

The governing system of all turbines is a very important factor and more so in case of high head power plants, operating under considerable heads. The governing system must provide very close control of the load, speed and water pressure fluctuations. The needle operating the nozzle give the desired undiffused flow for the turbine but for preventing the machine from running away due to load rejections we should have some device by which we could diffuse the jet rapidly. This is done by the Seewar system. Here the needle shaft contains a number of slanting plates the tips of which at steady loads are kept closely flush with the contour of the needle head thus allowing a compact cylindrical jet to be formed at all steady loads. In the event of the sudden drop in load, the slanting plates are caused by the automatic governor to protrude through the slots in the needle head rapidly in the jet, these slanting plates give a rotary motion to the water. The initial vortex is greatly enhanced outside the nozzle, causes the jet to be completely broken up into a hollow cone when by the energy imparted to the runner is rapidly destroyed. Simultaneously the needle advances to a position corresponding to the changed load and diffuse plates are withdrawn into a new flush position within the needle head. This gear has been extensively used. The gear, operates with the automatic governor, which controls the needle and its serve motor through a steering valve aranged in the centre of the needle servomotor. The diffuser comes into operation much more quickly than the needle and as such ensures better performance. This type of diffuser control are incorporated in the turbines of the Bhira Plant and the Khopoli Plant of Tatas in Bombay.

The New Reversible Pump Turbine

This is a new development in the manufacture of turbines. Due to the growing tendency of interconnecting steam and Hydro plants and the growing demand of water, the Hydro plants are being extensively used to take care of peaks and when the system is having light loads. The excessive power from steam power stations are used to pump the water back from the tail race of turbines to the head pond pumping could be done by using independent pumps but this is not a very economical propostion. The present day practice is to use pump turbines. The design is such that it could be used both as a pump and as turbine on account of this dual function, the pump turbine is developed as a two speed unit so that it could be run at proper R.P.M. for best overall efficiency when pumping as well as when generating power. The pump turbines have a very promising future. In the Big Thomson project on the Colorado river at the Flat Iron power plant pump turbine of 12000 H.P. is connected to a 10,000 kW generator which works as a motor when turbine is used as pump. A pump turbine is being installed at Hiwasse project of T.V.A. It is driven by a 102,000 H. P. motor when it is worked as pump and as a turbine it develops about 85,000 H.P. As a pump it is capable of pumping 4000 c. f. s. against a head of 300 ft. The Ontario Power Commission at Niagara according to agreement with the authorities are permitted to draw more water during nights. It is proposed to pump up this extra water during nights into a forebay at nights and let down the water to the power station below after passing the water through pump turbines of 38000 H. P. each. The installed capacity of the pump turbine plant would be 228,000 H. P. There is bound to be a large scope for pumped storage plants in India at a very near future date.

The Midget Hydro Units

Midget hydro power plants are of very small capacity units which are extensively used in U.S.A. Some plants of this type are developed by the Wisconsin Power Company. The plant consists of installing the turbine as shown in Fig. 4 in the sluice of the dam and locating the generator outside as in the figure. The Power House is an integral part of the dam. Fixed blade propellor turbines designed for the low head available is connected to an induction motor which is used to operate as a generator. The water from the head gates is directed to the runner by a series of stationary vanes. The turbine is not provided with any governor. The entire station is semi automatic in operation. In case of the generating unit tripping off the line or should the line become disconnected from the rest of the system, the generator will continue to run at full runaway speed until the line is energized. The starting controller then applies 50% of the voltage to the generator reducing the speed of the unit. After a short time delay the starting time closes and causes full voltage to be applied. The speed of the unit then drops to the normal operating speed. The plant is an unattended station. This type of plant constructed by Wisconsin Michigan Power Co., has a capacity of 1800 kW. The single generator is of induction type. The plant is of semi outdoor type built of concrete and structural glass block. (Fig. 5) There is no indoor crane but outdoor travelling hoist which is able to transfer materials and apparatus through a hatch. The height of the building is only 12 ft. The induction generator used in this plan is a squirrel cage motor with a low resistance rotor driven slightly above its

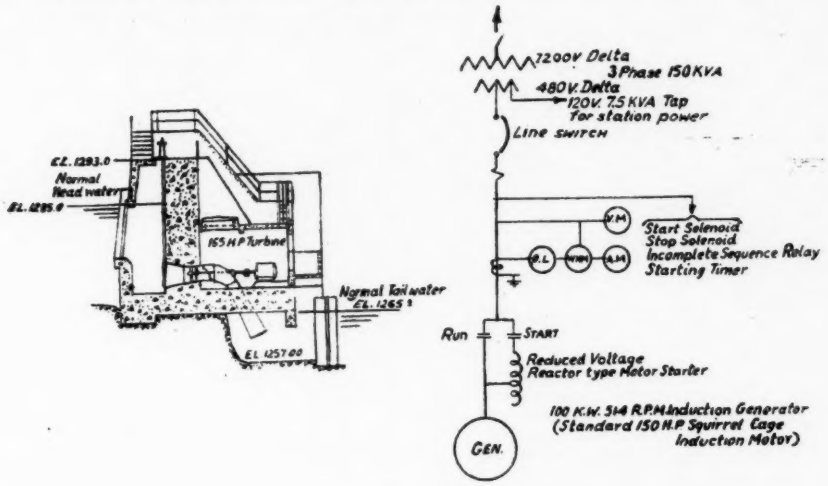

FIG. 4

LEFT: SECTIONAL ELEVATION OF LOWER PAINT PLANT
RIGHT: SINGLE-LINE DIAGRAM OF LOWER PAINT PLANT

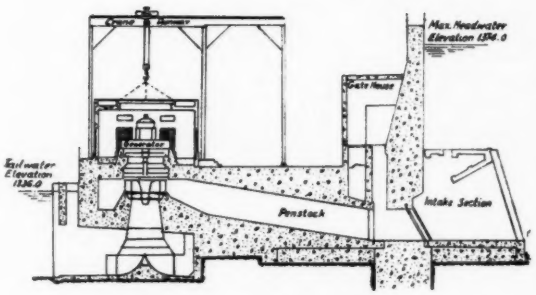

FIG. 5

SECTIONAL ELEVATION OF WAY DAM PLANT

synchronous speed. The turbine is a vertical shaft fixed propeller turbine. This induction type generator has no excites and gets its power from other stations.

The station is automatic in operation with the head gate open, all protective devices set and the generator breaker open. By operating the master control switch. the turbine gates open and when the generator picks up to the desired speed, the generator break is closed and the generator is then connected to the energized end. Necessary protective devices, alarms, etc are included so that the station is made completely fool proof.

The Monoblock Generator Plant

This is one of the latest developments made in small size hydrostations in France (Castet prototype Hydraulic Power Station in France). These units allow great economy in civil engineering work. In the present case i. e. the Castet plant the capacity is 2000 H. P. This is a low head plant and Fig. 6 gives the details of the plant. The monoblock sets reduces the size of the station compared to the classical sets of identical rating. The turbine and the generator are completely submerged and cooled by surrounding water. As could be seen from the figure the station building is completely eliminated and the conventional intake and draft tube are joined together. The straight draft tube reduces the excavation considerably. These plants almost completely eliminates the cold air-circulation and fire protection equipment. As these small stations are for automatic running and remote control, from a central station. This reduces the installations for maintenance and staff. It has been found that savings of about 40% could be achieved in such small plants. These stations are often called the "Micro Power Stations" can be situated on ordinary water currents with relatively low heads and due to their very low cost they could be easily financed by Industrial undertakings and Municipalities. If these stations are meant for power supply locally, the losses are minimum. By adopting such small stations, which cost very little financial commitment, these stations are quick to erect and easy to maintain. It is also possible to use these not only as a generator but also as a pump with satisfactory efficiencies. Thus these monoblock units are very useful for tidal power stations.

At the Castet power station in France (Fig. 6) two units are provided. Each unit takes 440 c.f.s. the rated horse power of each unit is 1100 H.P. at a head of 24.8 ft. This station is remote controlled from the Hourat Power Station, 9 miles away from the Castet station. Starting and stopping of each set, regulation of turbine blades and disconnection of the main transformer is done by the remote control. The sets are started with turbine rotor blades closed, using the asynchronous generator as a synchronous motor. This simplifies the starting proceedure.

The sets are placed at the entrance of a concial

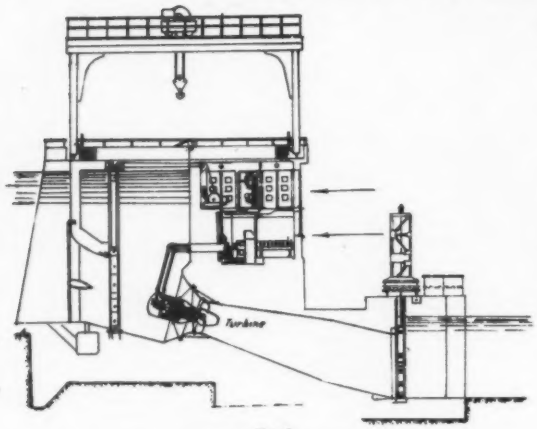

FIG. 6
CASTET POWER STATION - SECTION ALONG THE AXIS OF ONE SET

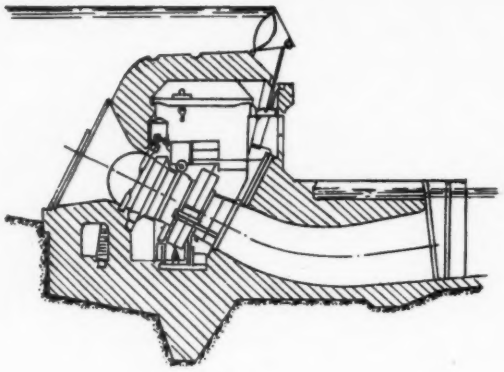

FIG. 7
STRAIGHT THROUGH TURBINE GENERATOR

tube in the dam masonry which serves as diffuser for the turbine. The turbine is of the axial propeller type. The distributor is fixed and the rotor blades are moveable. The alternator has the form of a dum situated on the upstream side of the turbine rotor. The cooling is effected by oil which is circulated by a centrifugal pump attached to the rotor. The servomotor for control of the turbine rotor blades is placed inside the turbine rotor. The oil which is kept underpressure not only prevent water leaking through and also cool the generators. The reduction in dimensions of the alternator are striking. The axiad dimensions are same as the classical type but the iameter is reduced by more than half. The weight of such a set is about 1/5 or 1/6 of the usual valve.

In India there are innumerable small streams carrying water only during the raining season and if small storage dams incorporating these monoblock sets are built, a considerable amount of rural electrificatin work could be done very economically. Every small dam or ancient built could incorporate these units in their sluices and develop power cheaply which could be used by the community.

In Austria these small units are termed the Straight-Through turbine generator and this has been devised for the economical development of relatively small amounts of power at low head. In such cases, conventional plants would be relatively expensive (Fig. 7).

The other developments that are taking place are: (1) The adoption of pump storage schemes and (2) The underground Hydro power stations.

Pump Storage Schemes

In the earlier pages of the report the importance of water power and the flexibility of hydroplants has already been explained in detail. In the interconnected system of steam and hydropower, a lot of power would be available at night and at times of light load. This power could be purchased at a very low rate and used to pump up water from the tail race channel and use the water for generating power at peak load periods and sell it at a higher rate. In some installations where extra power is available it is used for pumping water to the head race. The pump storage acts in a storage of electrical energy which could be used at any time.

Generally it was the original practice to install seperate pumps driven by motors for pumping some of the tail race water to an artificial lake in order to increase the volume of water stored therein. This incidentally increases the head of the plant and more water is conserved Adoption of separate motor-pump involves extra cost and space. A later development is the use of the generator as a synchronous motor and the pump is connected to the generator on one side and the turbine is connected on the other side of the generator. But the latest development is the use of pump turbines. The same pump works as a turbine when run in the opposite direction. The alternator itself is used as a motor for driving the pump. Here both the turbine and generator are of dual function. Except that the machines have to run at two different speeds as motor and generator respectively the entire set up is very satisfactory in operation. The unit is designed as pump and the efficiency as turbine is a little lower than that of the pump. The Flat-iron power plant of the Big Thomson Projects of the Upper Colorado has in it a pump turbine. As a motor, the generator takes 13,000 H. P. at 300 R. P. M. and used for pumping water from the tail race to the carterlake at periods of low load. As a generator it develops 8500 kW. at 257 R. P. M.

At the Hiwasse dams of the T. V. A. a pump turbine is being installed. As a pump it delivers 4000 c.f.s. at 300 ft. head. As a motor the unit absorbs 102,000 H. P.

At Niagara Falls (Canadian) one of the features of the Adam Beck Plant II is the installation of a pump turbine plant. The excess waters in the Niagara river that is made available for storage at night is pumped upto an artifiical lake by 6 feathering type Francis turbines, each of 53,500 H.P.

With the rapid industrialisation of the country

there is bound to be great demand for power and it will be necessary to conserve all available water as demand arises. There is going to be a very wide field in this direction.

The Underground Power Plants

There is a growing tendency to go in for outdoor power plants and underground power plants in the case of Hydro Power Plants. The design of machinery has developed so much that outdoor stations are as reliable and convenient in operation as the more conventional fully housed plant. Outdoor plants have also reuced the cost of plant and saves a lot of time. The underground plant has a main advantage of giving a very wide opportunity to the designer much more freedom in locating the conduits and the plant. The surface contours are of little consequence. The other advantages of an underground plant are:

(1) It vastly reduces the length, weight and cost of the penstocks and the reduction in length increases the overall efficiency of the power plant due to reduction loss;

(2) An underground plant is safe against rock, earth or snow avalanches;

(3) It is better sheltered against climatic extremes,

(4) An underground plant is less expensive than a surface or overground plant;

(5) From the strategic view point it is the safest;

(6) The maintenance charges for the penstock and variations of temperature inside the station being not much, the heating or cooling of the plant is not a very serious factor;

(7) The reduction in length and size of the feeder penstocks improve the regulating conditions.

The mordern techniques of tunnelling has so much advanced that tunnels and caverns can be driven in any type of rock. The lining techniques and the perfection in the type of stresses that come in the concrete and the lining has enabled the engineer to excavate pressure tunnels and caverns for locating the machine very economically.

The underground station is not a new innovation. Sweden built its underground station as early as 1897 and Germany in 1904 and France in 1919. Particularly the first and second world wars has given a stimulus for this type of power plant construction. There was more than 7 million horse power installed capacity by 1953 in underground stations. Sweden has about 1200,000 kW of its power plant underground. It is not only the strategic considerations that favoured the construction of under plants but it is the economy. In Norway also there are a number of underground stations and many big plants are being constructed underground and a legislation exists in Scandinavian countries that plants above 2000 kW capacity should be located as far as possible underground.

The Brommat plant in France with a head of 855 ft. has its power plant underground with an installed capacity of 186,000 kW. The Innert Kirchen in Switzerland has a capacity of 210,000 H. P. located underground in the Alps. It has a head of 2235 ft. The Harspranget plant in the Artic region of Sweden has a capacity of 377,000 kW and head is 346 ft. The Santa Messenna in Italy with a head of 1505 ft. has a capacity of 284,000 kW is located underground.

From a few examples enumerated above it can be clearly seen that there is a growing tendency for locating the hydropower plants underground. As far as India is concerned the location of power plants underground is very important factor from the point of economy. To think of the underground plants from the point of view of strategic consideration is simply foolhardy in this atomic age. Almost all our water power potential is in Western and Eastern ghats and up in the Himalayas. The country lends itself admirable for underground plants. At present if surface plants are to be built India has to depend on outside countries for enormous quantities of steel needed for the penstocks. India is not poor in tunnelling technique. The Bhor and Tall ghat tunnels of the Central Railway, the 50 ft. diameter tunnels of Bhakra Nangal the various tunnels of the Tata Hydro System etc., are standing examples of our advancement in tunnelling technique.

It is gratifying that an underground power plant has already been under progress at Maithon of the D.V.C. Projects. The Koyna Hydro project of Bombay has decided to have the plant underground with an ultimate capacity of nearly half a million kW. It is in the interest of economy that power schemes that are likely to be taken up later to consider the possibilities of adopting underground penstocks and underground stations. The Sharavati Valley Project of Mysore which will have a final capacity of about 0.7 million H.P. and the Kalinadi projects of Dharwar District, the Barapole hydro project of Coorg should consider the possibilities of locating power plants underground and saving considerable amounts of currency going out of the country and using the available talents in the country and also hasten the construction of the plants. Now India has decided to set up heavy electrical industry including the turbines, switchgear etc. it will be very advantageous and economical for the country to take to underground hydro plants without any hesitation.

Finally I would like to conclude this paper by expressing my very sincere thanks to my professor Shri N. S. Govinda Rao who encouraged me to put out this article and to all my colleagues and the office staff who were helpful in preparing sketches and typing.

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Impressions of My Tour Abroad

By D. MOOKERJEA

On my way to the States, where I was assigned for this study trip, I took the opportunity of spending a few days in Europe to visit some engineering works of interest. I visited the Central Hydraulics Laboratory at Chateau a few miles away from Paris. I was amazed to see the several model studies that were in progress in connection with Rance River Tidal Power Plant. This research station has also very succesfully carried out certain studies regarding removal of a sandbar from the mouth of a river for facilities of inland navigation.

I visited a microcenter developed by the Electricite de France where hydro-power is being generated from a small channel with drop of 5′/6′. The water is being passed through a Duralomin syphon inside which the turbines and generators have been housed. The generator is further protected by an oil chamber.

The Societe de Enterprises, who are fabricating the steelworks for Durgapur Steam Station took me round to show some of the very major steel fabricating jobs undertaken by them in and around Paris.

The Ministry of Public Works, France, took me for a visit to the Seine River Navigation System. Several barrages have been constructed across the Seine to control the draft for navigation during low water stage. The discharge of the river varies from 15 m^3 sec to 2400 m^3/sec. The barges that ply in this system are all self-propelled with push-tow arrangements. They are privately owned and usualy run by a family consisting of husband and wife. No toll is levied for plying in the river and the entire maintenance cost of the system is borne by the Government as in the case of highways. The system handles an approximate annual traffic of 6 to 7 million tons. The barges are 38.50 m in length, 5.5 m in width and the draft is 2.20 m. At each barrage site there are two locks, one for large ships and the other for smaller barges. These locks also cater for the inland transport for the Port of Paris. The Ministry of Public Works also arranged for a visit to the projected development of the Port of Paris and the construction of Andresy Barrage across the Seine about 60 miles from Paris.

I took a short trip to Scotland and paid a visit to the welknown steel balanced cantilever bridge on the Firth of Forth at Queensberry a few miles north of Edinburgh. The construction of such a tall bridge must have been a superb engineering feat in the day in which it was built.

After a week's stay in Washington D. C. where the International Center arranged for a short orientation, I proceeded to Denver, Colorado. On my way to Denver, I spent a day in Chicago, visiting the Lake Michigan, the ship locks connecting the Chicago river running through the city and the Lake. There is a difference in elevation of 3 feet and the locks are meant for large ocean-going vessels. I also visited some tall buildings constructed only with steel and glass. I also visited the Chicago Natural History and Science Museum. These are really places where one could spend days and learn many things.

At Denver, I spent about four weeks in the following divisions and visited the hydraulics laboratory attached to the United States Bureau of Reclamation, Chief Engineer's Design Office:

(i) Economic Studies;
(ii) Sedimentation Studies;
(iii) Hydrology and Water Utilisation Branch;
(iv) Operation and Maintenance Branch.

The Chief Engineer's office is mainly concerned with designs and the office has been split up into many specialized divisions. It is, therefore, difficult for people like us from India to find out a suitable answer to any question that comes to our mind. It also appeared to me that there were too many superior establishments and too much of watertight compartments.

The conception about the development of irrigation in the United States is not also similar to that of ours. In assessing benefits from an irrigation project, the U. S. Government not only takes into account

direct benefits from irrigation, they lay equal emphasis on the indirect benefits from irrigation such as—

(a) profits of local wholesalers and retailers from handling the increase in sales of farm products;

(b) profits of all other enterprises between the farm and the final consumers from handling, processing and marketing the increase in sales of farm products locally and elsewhere;

(c) profits of all enterprise from supplying goods and services for the increase in farm purchases for family living and production expenses.

The Public Irrigation Benefits like :
(i) settlement opportunities;
(ii) investment opportunities;
(iii) community facilities and services;
(iv) stabilisation of local and regional economy.
are given due weightage in the financial analysis and to arrive at a cost benefit ratio.

There has been a general impression in this country that irrigation projects have not borne fruit quickly enough and that the waters are not being promptly utilised. In this context I reviewed the progress of the Columbia Basin Project which aims at an irrigation of one million acres. The Grand Coulee Dam, which was started in 1933, was completed in 1941. By 1950, the area under irrigation was 4350 acres, by 1955 it was 1,49,200 acres. By 1961 the anticipated area is around 6,00,000 acres. In spite of this slow rate of development of irrigation, the U. S. Government stated in a report about the project: "A new agricultural empire with its production of farm commodities, development of towers, establishment of social structures, industrial expansion, development of market outlets and associated activities is just beginning to assert itself in the largest single irrigation project in the Nation."

To make a largescale irrigation project successful, they have paid equal attention to the development of associated and subsidiary industries like, fertiliser activity, storage of grains, cold storage plants, development of frozen food, and marketing and transport facility. Without these subsidiary industries neither the employment potential nor the standard of living for common men can be raised.

In the United States, the cost of flood control and navigation is non-reimbursable. The water rates for irrigation also do not have to meet the interest charges. These concessions have been made with a view to inducing the farmers to go in for more production and indirectly help the national economy. In the United States under the present (1932) law, a finding of 'feasibility' approved by the Secretary of the Interior and sent to the President and the Congress, is sufficient to authorise the construction of a Reclamation Project, if the Secretary finds that the proposed project has engineering feasibility and if the estimated cost less allocation to flood control navigation, fish and wild life will *probably* be returned to the United States. Because of this feature, the finding of the feasibility procedure is sometimes referred to as an automatic authorisation.

President Eisenhower, in May, 1954, while establishing a Cabinet Committee on Water Resources in the United States, stated "The conservation and use which we make of the water resources of our Nation may in large measure determine our future progress and the standard of living of our citizens. If we are to advance agricultually and industrialy we must shake the best use of every drop of water, which falls on our soil or which can be extracted from the oceans".

India has a great potential for utilisation of water resources. It has been roughly estimated that the total flow of surface waters alone in India is of the order of 1350 million acre feet. Of this it should be possible to put to beneficial use about 450 millin acre feet. We have not up till now been able to use even 100 million acre feet.

I visited the Colorado Big Thompson Project in which the surplus waters of the Colorado basin are pumped and conveyed through a 13-mile long tunnel across the Continental Divide (Rockies). This water is then utilised for geneating hydro-power at different places and ultimately used for irrigation. The capacity of the tunnel through which water is brought in is only 550 cusecs. The ultimate capacity of some of the canals at downstream end is around 1,000, cusecs. The capital outlay on this project is $160,000,000 or Rs. 80 crores. It is the the revenue from power which will pay for for the project cost. The total installed capacity of the system is 1,83,950 kW though the available storage capacity is only 994,240 acre feet.

After a brief stay at Denver I went out on a study trip for more than eight weeks covering practically the entire States. On March 31 I visited the Grand Coulee Dam, the largest manmade concrete structure in the world and the largest hydro-power station in the States, perhaps, in the world. 12 giant size pumps, each having a capacity of nearly 1,300 cusecs, are used to pump water to a height of 280 feet for commanding the irrigable area. This procedure had to be resorted to as the height of the dam had to be limited in order to keep the reservoir elevation within the territory of the United States, because the Columbia river originates in Canada. The irrigation is also mostly done by pumping water from one valley to the other and from the canal to the laterals and from laterals to farms. I went to see the constructions of some dams like the Priest Rapids, the Trinity etc., and also visited several other completed dams like the Shasta, Mc Mary, Dalles, Bonneville and the Dexter. From April 9 to 16 I visited the Central Valley Project in the State of California. There, a masterpiece of engineering has been achieved in transferring a large block of water from northern California to southern California across the Delta area. The State of California has many problems similar to those of West Bengal. There have been controversies regarding the use of water in the different parts of the State. The State of California has prepared a master plan, known as "The California Water Plan",

after observation and studies for several years of the water resources throughout the State. This plan takes into account development of all water resources and requirements of water for various interests like agriculture, industry, domestic water supply etc. This delta area has also had the problems of salinity intrusion, the bed of rivers rising above the surrounding country level and also of severe floods. From Sacramento I proceeded to San Francisco and on April 18 I visited the Bay model set up by the Corps of Engineers, U. S. Army, to study—

(i) the Salinity Intrusion in the Valley;
(ii) to find ways and means to reduce the cost of dredging at the mouth of the harbour; and
(iii) to determine alternate sources of water supply to all the cities now being developed in that area.

After leaving San Francisco, I went to Los Angeles and visited the arrangements of water supply to the Metropolitan Water District through the Colorado River Aqueduct System. It is a unique feat of engineering performed by the U.S. Government for supply of water to several important stratgic industries and for domestic supply in and around the city of Los Angeles. Next I visited the Hoover Dam. Incidentally, this is the highest dam in the United States, and the reservoir formed by the dam is reported to be the largest man-made lake in the world. The capacity of the lake is over 31 million acre ft. It was also understood that since the construction of the dam, the overflow spillways had functioned only once in the year 1942. To increase the life of this dam, the U. S. Government have decided to build some two or three dams in the upper Colorado. One such dam which will be almost as big and as high as Hoover Dam is now under construction at Glen Canyon. I also took the opportunity of visiting the Grand Canyon through which the Colorado is flowing. The geological age of the Canyon is reported to be over 7 million years. This is one of the seven wonders of the world.

Next I visited middle Rio Grande Project at Albuquerque, New Mexico, from April 28 to May 9. This area has much in common with our village life in U. P. and central India. Most of the abode houses are mud-built and thatched and the roads are also dusty and undeveloped. There are some old and antique type of diversion works and innundation canals from the Rio Grande. This is a comparatively small river and a discharge of 6/8000 cusecs is considered to be a flood stage and keeps the entire organisation on its toe. The river carries a large quantity of sediment and planning of the canal heads has not been scientific with the result that the take-offs are favourable for more sedimentation. Settling basins have, in some cases, been provided at the head of the canals and they get filled up by sediment in one season. Continuous dredging of these basins at a considerable maintenance cost has been resorted to. The canals are not also well formed with proper slopes with the result that there has been bank slides and attempts are now being made to provide gravel lining. Owing to large silt content, the river Rio Grande has too many loops and meanders. Channeling of the river by shortening the loops at certain places have been attempted to reduce the flood hazard in certain areas. Extensive mild steel jetty work has been done to prevent bank erosion so that the river may not attack the levees. Here also, due to premature reclamation of valley lands by levees, the bed level of the river is higher than the surrounding country level.

After spending a couple of days at Amarillo, Texas, I went to Vicksburg (Miss) and visited the Waterways Experiment Station under the Corps of Engineers. I paid a visit to the Mississippi River Commission and discussed with their engineers the method of bank protection of the river by articulated concrete matting and asphalt lining of the banks. I also visited the Mississipi Basin model reported to be the largest hydraulic model in the world at Jackson, Miss, which has been set up to study and predict the flood conditions in the Mississippi and to determine the heights of levees at various points. Detailed studies regarding flood bypasses and shortening of the loops are however being studied in a largescale model at Vicksburg.

I spent a fewdays with the TVA and visited the Norris Dam, Fort Loudon Dam, an experimental agriculture Farm, Atomic Energy Commission Museum located at Oakridge Tennessee. I had also discussed with various sections about their flood control operation, water control planning, financial and economic justification of TVA as well as the special design features of Wilson Lock now under construction, which is reported to be the biggest lock in the world. The size of the chamber will be $600' \times 110' \times 100'$. The design of this lock presented special problems and considerable studies had to be made in a large scale 1/16 model. As this lock is built alongside an existing dam and lock, certain special features had also to be adopted during construction.

In this connection I made certain enquiries about the administrative set-up of the TVA. The present Chairman of the TVA is a retired Civil Engineer of the Army Corps of Engineers. The Chief Executive Officer, who is designated as the General Manager is also a Civil Engineer, who has been chosen from the civil engineering cadre of the TVA.

Before I left the United States, I visited the St. Lawrence Seaway and Power Project near Massena, New York. The St. Lawrence Seaway Project has been undertaken jointly by the Federal Governments of Canada and the United States. Similarly the St. Lawrence Power Project is being developed by the Power Authority of the State of New York jointly with the Hydro Electric Power Commisstion of Ontario Canada. The entire project, which is a little over a billion dollars, is to be shared by the two countries on an agreed basis. This is perhaps a unique example to the nations of the present-day world how by co-operative effort and joint venture, vast water resources can be developed and put to the beneficial use of mankind. The combined power-plant for the two countries have an installed capacity to the extent of 1.8 million kW. Similarly, the seaway (improvement and deepening of the channel and construction of locks) would provide the rapidly increasing demand for more and

better facilities for use of the St. Lawrence river as a modern ship channel for maritime commerce.

Co-operation and co-ordination among the two seaway entities and the two power agencies have been notable throughout the design and construction phase of the overall project. It is surely an eye-opener to many other countries in the world how through mutual co-operation and co-ordination the neighbouring countries can benefit from each other. This project has been under construction since 1954 and it is expected to be completed by 1959. In addition to the major dams, powerhouses and locks, the combined project consists of extensive works like dikes, transmission lines, transforming facilities, relocation of highways, railroads, existing navigation facilities, homes, villages and existing business concerns.

I left the United States on June 1 for India by the Pacific route and spent four days at Tokyo, Japan. The officials of the Indian Embassy were kind enough to arrange some visits through the courtesy of the Government of Japan. At Tokyo, I visited some small-scale industries including a factory for manufacture of various kind of decorative electric lamps and a watch manufacturing factory. I visited also the Industrial Art Institute of the Ministry of International Trade & Industry, where considerable research work is being done for the promotion of Japanese art and industry throughout the world. I visited the Tokyo factory of M/s. Mitsui Precise Instrument Manufacturing Company Limited. This factory is manufacturing various types of precision lathes, milling machines, air compressors of different capacity and three-wheeled motor trucks. I visited the factory of Messrs. Tokyo Shibaura Electric Co. Ltd., who are the manufacturers of very large generators, turbines, switchgears, circuit-breakers and various types of electrical installations required for both hydro and steam-power stations. The same evening I went to Yokohama and visited the ship building yard of Shin Mitsubishi Heavy Industry Co. Ltd., where ships of 40,000-ton capacity are being built. They are also manufacturing in their own factory all the components required for the building of large ocean-going vessels including large boilers.

In course of my visit in these countries I noticed that both the Western and Eastern countries have taken very effective steps for early recovery from the effects of the Second World War. The people, in general, are also anxious to work hard to rebuild the economy of their country which almost completely broke down during the War.

In the United States also they are anxious to improve the living condition and standard of common labour and farmers. Some of the things which I observed during my trip in the United States are summarised below:

(*a*) The extensive use of timber poles for carrying telegraph, telephone and even high tension electric lines throughout the United States, which produces more than 100 million tons of steel per year, is really worthy of emulation in our country. This would greatly help in conserving steel for use in industrial development. In the matter of water resources development also, the way how the indirect benefits to the country and, thereby, to the nation are evaluated and taken into account while determining the feasibiliy of the projects is worthy of serious consideration and application in this country, the economy of which is primarly dependent on agriculture.

(*b*) With the gradual development of large-scale industries in our country and the consequent enlargement of scope of employment of men in such industries, mechanization of projects and adoption of remote control arrangements in various features of the working of the projects as have been practiced in the U.S.A. would not only be useful but necessary. In the U.S.A practically all construction jobs are handled by contractors. Only the placement and selection of right type of equipment and the planning of the construction are done by the engineers working under the private sector. In matters of irrigation also, the responsibility of the Project authorities is only limited to the storage reservoirs and supply into the major canal systems. In most cases, the improvement, maintenance and operation of the distribution system, the planning of water indents and its distribution to various users is the respnsibility of Irrigation Water Districts which in that country, are very efficient and well-managed bodies. The crop planning, the crop rotation, the water requirement of crops are all managed and controller by the Irrigation Districts in consultation with the Soil Conservation Service under the Department of Agriculture.

(*c*) The United States has adopted complete mechanisation in the execution of works, and extensive use of electronic devices and remote control operating arrangements. Unfortunately, these cannot be readily adopted by us until the machines and their spare parts are locally manufactured in our country. It is only then that men now employed in the execution of river valley projects could be diverted and found suitable employment in the industries. To achieve this, we must have more steel produced and more manufacturing industries developed in our country. Until then we should adopt a balanced use of men and equipment in our projects, so that neither economy is overlooked nor any large-scale unemployment problem is created.

(d) Generation of large blocks of hydropower and extensive use of electricity throughout the country for development of industries have played significant part in paying for the cost of such otherwise much too expensive projects. Large-scale industrialisation has made it possible for the electricity to bear the major share of the projects. The share of cost allocable to flood control is borne entirely by the Federal Government and the irrigation projects do not have to bear the interest charges on the capital outlay allocable to irrigation.

(*e*) Another significant factor connected with my sphere of study which attracted my notice is that agriculture and irrigation operations in that country

[*Continued on page* 34

Betterment Levy

By C. S. PARTHASARATHY

What is betterment levy? Let us endeavour to define it at the very outset. It is a capital tax based on the principle of the Government recovering, from the beneficiaries, a portion of the 'unearned' benefits that accrue to land, as a result of the availability of irrigation facilities from irrigation and river valley projects. The idea underlying the levy is that a small proportion of the additional value that accrues to the land by the advent of irrigation facilities should be made available for further capital expenditure. Unless this source of revenue is tapped, it will be very difficult to increase the scope of the future for development of irrigation and finance them on the scale we all wish to for stepping up our food production to meet the increasing needs of our growing population. The major and medium irrigation projects included in the First and Second Five Year Plans are, at present, estimated to cost over Rs. 1200 crores which, it will be agreed, is a colossal sum, especially when compared with the total investment of about Rs. 110 crores on first-class irrigation works during the entire British period and are expected to bring about 37 million acres of additional land under irrigation. In addition, the two Plans included minor irrigation works and tubewells estimted to cost another about Rs. 200 to bring under irrigation about 19 million acres of land under irrigation. If we are desirous of going ahead in the coming years at this or greater pace of development of irrigation, further enormous sums of money are required. Otherwise, it will be well-nigh impossible to undertake similar works in such magnitude.

Finance Commission's (1957) Findings

2. There is yet another point. It was worked out that the average net revenue from the irrigation works of undivided India was 8% of the capital outlay. If our irrigation works have continued to prove to be profitable ventures, perhaps there would not have been much anxiety about their economics and working; but facts and figures have a different story to tell. The Second Finance Commission (1957) examined this question and observed that "a disturbing feature in the revenue position of most States was the deterioration in the net receipts from irrigation" unertakings. The Commission's analysis of the net return in respect of irrigation works other than multipurpose projects is given below:

Net receipt from irrigation works (commercial) after deduction of interest charges

(Rs. in lakhs)

State	1951-52	1952-53	1953-54	1954-55	1955-56
Andhra	..	..	(+) 40.60	(—) 221.74	(—) 230.00
Assam	..	..	..	..	..
Bihar	(—) 28.32	(—) 3.04	(—) 29.84	(—) 46.67	(—) 47.00
Bombay	(—) 28.03	(—) 17.62	(—) 28.78	(—) 48.05	(—) 64.00
Madhya Pradesh	..	..	..	..	..
Madras	(—) 97.90	(—) 180.31	(—) 251.96	(—) 106.68	(—) 201.00
Orissa	(—) 10.67	(—) 12.32	(—) 19.39	(—) 23.69	(—) 40.00
Punjab	(+) 57.89	(+) 131.19	(+) 185.85	(+) 138.97	(+) 63.00
Uttar Pradesh	(+) 136.31	(+) 96.21	(+) 192.87	(+) 208.41	(+) 47.00
W. Bengal	(—) 21.13	(—) 22.69	(—) 11.75	(—) 29.17	(—) 19.00
Hyderabad	(—) 8.04	(—) 11.00	(—) 9.25	(—) 9.25	(—) 11.00
Madhya Bharat	..	..	..	..	(+) 12.00
Mysore	(+) 3.14	(+) 9.30	(+) 2.43	(+) 4.38	(+) 7.00
Pepsu	(+) 36.97	(+) 35.03	(+) 40.28	(+) 34.47	(+) 1.00
Rajasthan	(+) 9.24	(—) 5.77	(—) 16.95	(+) 4.41	..
Saurashtra	(—) 5.09	(—) 8.86	(—) 13.41	(—) 18.39	(—) 25.00
Travancore Cochin	(—) 0.47	(—) 1.07	(—) 0.96	(—) 3.84	(—) 7.00
Total	(+) 43.90	(+) 9.05	(+) 79.74	(—) 116.84	(—) 514.00

Note : Interest not debited to the major head "17-Irrigation, Navigation, Embankment and Drainage Works (Commercial)" in Hyderabad, Madhya Bharat, Mysore and Pepsu.

It will be seen that at the end of the first five year plan, only two States, namely, Punjab and Uttar Pradesh were able to obtain a net return from productive irrigation works after meeting interest and other charges. The Commission apprehend that some time towards the end of the second five year plan period, when some of these projects will be completed, the impact on the revenue budgets of the results of their working will cause anxiety.

Recommendation of the U. N. Panel of Experts (1957)

3. A Panel of Experts appointed by the United Nations in 1956 for reviewing the administrative, economic and social implications of integrated river basin development have in their* report submitted to the U. N. in November, 1957 dealt with reimbursements on public investments and methods thereof and have observed as follows:—

> "It would seem natural to demand from those most directly benefited a total or partial payment of the funds in order to be able to apply them to other projects. How large a proportion is to be paid back by the direct beneficiaries would, of course, vary from case to case."
>
> "Sectors already enjoying a relatively better standard of living than that of the population as a whole should not benefit from the effect of a public investment without making adequate reimbursement. On the other hand, if the economic level of the group which receives the benefit has been very low, reimbursement should be restricted to a minimum."

One of the methods of reimbursement of the cost of the project recommended by this U. N. Panel of Experts is to levy special taxes on the increased value of the assets (predominantly used in agriculture). The Panel point out that a method occasionally used in cases or irrigation or drainage projects is to expropriate the land affected and that sometimes the cost of the project carried out in regions were latifundia community exist may be refunded not in money but in the shape of land, which may be sold to other persons, thus enabling the property to be divded into smaller holdings.

4. The Panel of Experts proceed a step further and say that "assessments on the increased value of properties may cover both direct and indirect benefits from a given project. When irrigation schemes are carried out, unirrigated properties adjacent to irrigated land will probably increase in value as a consequence of the influx of population into the area and its correspondingly greater economic activity. In such cases, a general property tax may be devised to pay for the indirect benefits and complementary special assessments may be imposed on the direct beneficiaries", and that "when an increase in land value is the basis for assessment, payments may come out of the increase in yearly income, so that the total contribution which does not normally exceed the cost of the undertaking may be spread over a reasonably long period." No doubt, they recognise that when fixing these charges the repayment capacity of the beneficiaries should also be borne in mind and the project should be sufficient profitable and attractive the user of land and water to enable him to make all scheduled payments and at the same time achieve a noticeable improvement in their standard of living.

5. The proper approach has, therefore, been considered to be to so educate the people that they accept such a levy and the ground for legislation for betterment levy should be prepared at a stage when the people are anxious that their irrigation project should be taken up and included in the Plan. The most important and difficult issue connected with the Second Five-Year Plan is the large gap in resources. Every possible effort has, therefore, to be made to add to them and an equitable way is to levy betterment contribution on areas receiving new or improved irrigation facilities. Areas irrigated by tubewells also derive secure irrigation and it would be equitable if the beneficiaries in such areas also pay betterment fees. Similarly, areas receiving protection from flood-relief and control works should be subject to this levy. By March '58, about 5.8 million acres of additional land would have received irrigation facilities from major and medium projects undertaken in the first plan; and another about 8 million acres are expected to be irrigated during the remaining period of the Second Plan, from similar schemes. Some more additional areas under tubewells and such other minor irrigation works which provide secure irrigation are also expected to be brought under irrigation during the Second Plan. Betterment levy on all these areas will evidently make a useful contribution to capital resources. These principles and urgent needs have been brought home to the State Governments by the Planning Commission,* from time to time.

Basis for Levy

6. The basis for evaluating the quantum of betterment levy proposed to be recovered from the beneficiaries by the Government is a vital point and differs in different States. The basis of betterment levy adopted by different States is summarised below:—

State	*Basis*
ACTS	
(i) ANDHRA PRADESH	(i) Increased value of land equated to 25 times the net additional income minus expenses incurred.
	(ii) Increase in value of land on the basis of market rate of dry or wet land in the area or its vicinity (Telengana).
(ii) ASSAM	Degree of benefits conferred on lands; proximity of the property to the flood-protection works; object is to recover the initial cost of scheme in full or in part.

* Refer pages 24-26 of the United Nations Report by a Panel of Experts on 'Integrated River Basin Development' (1958).

* Refer (*i*) Paras 57-67 of Chapter XXVI—Irrigation and Power of the "First Five Year Plan" (1952).
(*ii*) Paras 84-87 of Chapter XVII—Irrigation and Power—of the "Second Five Year Plan" (1956)

(iii) BOMBAY — Increase in capital value of land on the completion date over that on the construction date (or commencement of work).

(iv) KERALA (T-COCHIN) — The annual increase in the *gross produce* of each class of land which will be estimated with reference to the average of prices prevailing during the *five* years immediately preceding the date of such estimate. Twenty times the annual increase in the gross produce shall be deemed to be the increase in the capital value of land.

(v) MADRAS — Increase in capital value of land equated to 10 times annual increase in gross produce based on the average of prices prevailing during *three* years preceding commencement and *three* years after completion.

(vi) MYSORE — Increase in the capital value of land, according to rule making powers in fixing rates; subject to a maximum of Rs. 500/=per acre

(vii) ORISSA — Increase in capital value of land equated to ten times the annual increase in the gross produce based on the average of the prices prevailing during the 3 agricultural years immediately preceding the agricultural year in which water is first supplied for irrigation.

(viii) PUNJAB — Increase in value of land with reference to such date prior to commencement of work and estimated value with reference to such other date after such completion; provided (i) no betterment charges leviable where other charges are sufficient to cover the cost of the scheme and (ii) the amount of betterment charges recoverable will be limited to the difference between investment on the scheme and such part of it as may make it productive.

(ix) RAJASTHAN — Increase in capital value of land: type of irrigation and extent of betterment accruing to land.

(x) MADHYA PRADESH — The rate of betterment fees is determined in accordance with the following formula:—

$$Z = \frac{X}{Y \times 100} \times \frac{9}{4}$$ for the first *five* annual instalments

$$= \frac{X}{Y \times 100} \times \frac{9}{8}$$ for the next *ten* annual instalments

where

(i) X= cost of construction, improvement or extension of canal, incurred during the period of five years next preceding the date of issue of the notification.

(ii) Y= acreage of area benefited by the project.

(iii) Z= rate of betterment charges per acre per year.

(xi) HIMACHAL PRADESH — Capital cost, increase in value of land through irrigation facilities and increase in agricultural produce.

BILL

(xii) BIHAR

Betterment contribution at the following rates:—

	Rate of levy (per acre)
(a) In case of an irrigation work, not being a tube-well, river pumping set, storage dam or reservoir, where the flow of water is not perennial	Rs. 90/-
(b) In case of an irrigation work, not being a tub-well, river pumping set, storage dam or reservoir, where the flow of wate is perennial	Rs. 100/-
(e) In case of a tub-well, river pumping set storage dam or reservoir	Rs. 125/-
(d) In case of a flood-protection work, where the land benefited is not situated within an urban area; and	Rs. 50/-
(e) In case of a flood-protection work, where the land benefited is situated within an urban area.	Rs. 200/- per acre or 25% of its annual value.

7. An analysis of the foregoing table brings out the fact that the quantum or amount of betterment levy has, generally speaking, been based on one or more of the following criteria:—

(i) Increase in the market value of land benefited between the date of commencement and the date of completion of the project;

(ii) Difference between the market value of wet or irrigated, and unirrigated or dry lands in the project-affected area or its vicinity after the completion of the project;

(iii) Increase in the value of land equated to a multiple of the increase in the value of agricultural produce over a period of one year;

(iv) Increase in the yield of the principal crops; and

(v) Recovery of a portion of the capital cost of a project.

Other factors such as quality of soil, expenditure involved in converting dry into wet land, type of irrigation, etc., have generally been kept in view; and the proposed recovery is a certain fraction of the extra unearned benefit in different States. The basis for criteria (i) and (ii) above is the calculation of the market value. In respect of criterion (i), the comparison is

between the market value of land benefited between the date of commencement and the date of completion of a project; and, in the second, between the market value of irrigated and unirrigated land in the project area or in its vicinity, just before the levy commences. Similarly, the third and the fourth principles essentially hinge on differences in yield between land which is irrigated and land which is unirrigated and are, therefore, easy and intelligible. The hidden fact is that the second, third and fourth principles represent but different aspects of the same phenomenon, namely, the resultant increase in productivity of land arrising from, or due to, irrigation facilities afforded by a project.

8. The basis of increase in value of land between a date connected with the date of commencement of construction and a date depending on the date of completion of the project has the disadvantage that the ratios between the two rates obtaining on the two distant dates may be considerably affected by changes in rates of agricultural produce and consequent money values in the intervening period. Reforms in proprietory and tenancy laws of land may also affect the market values of the land, and the difference between these values over a period of years may not have a correct relationship between the benefits derived from such lands. It appears that a levy based on the difference in value of agricultural produce between the two different dates will also suffer from the same lacuna. The Plan has, however, recommended that betterment levy should be primarily related to increase in value of land although it may have some relation to the cost of the project. For purposes of illustration of some of the factors involved in the assessment of the betterment charges, a statement showing the basis on which betterment levy may be worked out for an irrigation project forms Annexure I.

Mode of Payment

9. Being a capital levy, betterment fees should either be paid in one lumpsum or recovered, normally, over a period of ten years and not more than 15 years. It may not be quite appropriate to recover such capital levy over a very long period of 25 to 30 years. It is also recommended that betterment charges may be recovered in the shape of land, by permitting the landowner to surrender to Government sufficient land in lieu of cash payment. Where there are large holdings, this would be preferable to recovery in cash. It would also be useful, under certain special circumstances, for the Government to take power to make the recovery in this manner, instead of leaving the option of such payment in land to the land-owner or the beneficiary. The underlying idea in advocating this mode of payment in land is that, by this means, the State will be able to obtain lands needed for:

(i) Settling persons whose lands are submerged by reservoirs or are acquired for other purposes connected with the project,
(ii) settlement of displaced persons,
(iii) effecting improvements in the agricultural economy of the villages under the project by consolidation of holdings, making uneconomic holdings economic, assignments of lands to landless labourers, etc.

10. A study of the State Acts and Bill for betterment levy brings out the fact that Andhra, Bombay, Mysore, Orissa, Punjab and Rajasthan had made suitable provision in their Acts to enable the land holder to pay the betterment fees in the shape of land. Assam, Madras, Kerala (T-Cochin) and Himachal Pradesh have made no such provision in their Acts. The Bihar Bill does not provide for such payment. Where provision has been made for payment in the shape of land, the option to do so has been left to the land owner or the beneficiary concerned. In other words, the law provides that the landowner may, at his option, pay the betterment levy either in the form of cash or by way of surrender of land of equivalent value. It appears that none of the States concerned has armed itself with powers to have the option of making a landowner or beneficiary surrender land in lieu of betterment fees, under certain special circumstances. Of course, there may be some regions in the country where the land holdings may be very small and payment of the levy in the shape of land may, perhaps, be out of question.

Date of Effect of the Levy

11. When should the betterment levy be imposed? Should it be charged before or as soon as the irrigation facilities are made available? Let us examine the relevent provisions in a few State Acts. The Andhra Act stipulates that no contribution shall be levied until the expiry of *three* years from the date of completion of the work but in Madras the period is *two* years. In Kerala (T-Cochin), the levy becomes payable two years after the date of provision of irrigation facilities to the land. According to the Orissa Act, betterment charges shall be payable on 15th day of April of the year next after the one following the kharif season in which irrigation facilities are first provided for the area or two months after the date of the award specifying, among others, the date on which such betterment charges shall be leviable; whichever is later. One question has been whether the charges could be recovered in advance of the advent of the irrigation facilities. In Kerala, attempts are made to collect advance contributions towards betterment levy even while launching projects such as Pothundy and Thannirmukkam Salt Water Barrier. The success of this venture should be eagerly watched. Generally speaking, two years seems to be a reasonable period after which the levy should become effective.

Application to Tubewell Areas

12. In regard to application of the levy to areas benefited by tubewell projects, the position, on an examination of the Acts and the Bill for the levy, emerges as under:

States	*Position according to Acts/Bill*
(*i*) Rajasthan Punjab Bombay	Tubewells included in the Act
(*ii*) Andhra Madras	In Andhra and Madras, wells have been mentioned; tubewells not mentioned specifically.

(*iii*) Kerala (T-Cochin)	Lift irrigation indicated; tubewells not specifically mentioned.
(*iv*) Assam Orissa.	Tubewells not included in the Act.
(*v*) Bihar	Bill applies to tubewells

Application to Flood-Control and Anti-Sea Erosion Works

13. It has also been emphasised that suitable amounts of betterment fees or contribution towards the cost of flood-control schemes are recovered from the beneficiaries. Betterment levy may be imposed not only on flood-control but also on anti-sea erosion works. A variety of opinions given below have been expressed on the proposal for flood-tax:—

(*i*) In case of irrigated lands which have received flood-protection also, the lands get double benefit. Such lands which did not receive irrigation before and were subjected to floods may be fetching less price than those which had no irrigation and which were not subjected to floods. In terms of produce also, there is additional increase on account of protection from floods in proportion to the percentage of high flood years. Therefore, when both irrigation and flood-protection are provided, the value of land would go up correspondingly and in addition to betterment levy on account of irrigation facilities, flood tax on account of flood-protection appears justified.

(*ii*) In addition to irrigated lands, there would normally be some non-irrigated, cultivable land and other immovable properties (such as buildings). If flood-tax is not charged, the owners of such lands and properties would acquire all the unearned income, through no effort of their own (due to higher prices after provision of flood-protection), without sharing it with the Government.

(*iii*) A levy of Re.1/-per acre may be proposed to be imposed on the area which is protected, with a view to meeting the cost of maintenanc of flood-relief works.

(*iv*) The aim should be to recover the full cost of the scheme.

(*v*) A recurring cess of Rs. 3/- to Rs. 4/8 per acre for extra area benefited may be proposed.

As regards the position in various States, betterment fees for areas protected from floods and erosion has been provided for in the Acts of the following States:—

Floods	*Erosion*
Assam	Assam
Andhra	Andhra
Bombay	
Madras	Madras
Mysore	Mysore
Himachal Pradesh	

Scale of Betterment Fees

14 As in the case of water rates, the scale of betterment fees that has been proposed, varies from State to State and from project to project in the same State depending on the type of irrigation, category of land, etc.

Generally, the State Acts do not specifically mention the scale or quantum of betterment charges to be imposed. They indicate the basis and provide for rule-making powers on the part of Government. For purposes of illustration, Appendix II portrays the scale of betterment fees proposed in respect of the Bhakra-Nangal project, for various types of irrigation namely, perennial, restricted-perennial, non-perennial, and improved irrigation on the existing canal systems. The table below sets out some of the proposed rates of betterment levy in a few States:—

State	*Approximate Scale of betterment levy (Rs.)*
Mysore	75 - 500
Bombay	100 - 600
Punjab	55 - 180
Rajasthan	75 - 180

A variety of methods that may be adopted by States in arriving at the scale of betterment fees and flood-tax are briefly described below:—

(*i*) In respect of flood-protection schemes, the area benefited may be proposed to be split into different parallel belts A, B, C & D depending on their distance from the protection works. The quantum of flood cess proposed may be as follows:—

Belt	*Percentage not exceeding the value of the property*
A	5%
B	4%
C	3%
D	2%

(*ii*) Levy of flat rates. For one region, the betterment charges vary from Rs. 60/- to Rs. 100/- per acre depending upon the category of land. For another zone, the following rates are proposed:—

	Rate per acre (Rs.)
(*a*) Perennial	
Existing area	50/-
New area	125/-
(*b*) Non-perennial	75/-

(*iii*) Impose betterment levy on all lands commanded by new canals at the rate of Rs.3/- for a period of five years and Rs. 4/8 for a period of 10 years per acre per year, on every

Rs. 100 per acre expended on the construction of the canal or part thereof, in excess of Rs. 50/-; and at half the above rate on amounts less than Rs. 50/- per acre so expended.

(*iv*) 50% or 25% of the increase in land value should be recovered from the beneficiaries, subject to a maximum of Rs. 200/- per acre or Rs. 100/- per acre respectively.

(*v*) The rate may be not less than Rs. 100/- and not more than Rs. 150/- per acre of command and may be about 2/3rd of the cost of the project, as far as possible.

(*vi*) The proposed rates of annual instalments of betterment levy are Rs. 10/8 and Rs. 17/8 per acre and may be about 1/7th of the additional benefit due to irrigation.

Revenues in Second Plan

15. When the Second Plan was formulated early in 1956, it was estimated that an additional revenue of Rs. 46.8 crores would be realised through betterment levy during the period of the Second Plan. An yield of Rs. 31.1 crores from betterment charges on areas benefited by the Bhakra Nangal, DVC, Hirakud was to be earmarked for repayment of loans by States concerned (mentioned below) to Central Government. The State-wise breakup of this amount is as follows:—

	Rs. Crores
(*i*) Orissa	1.6
(*ii*) Punjab	16.7
(*iii*) West Bengal	7.0
(*iv*) Rajasthan	5.8
Total:	31.1

The remaining amount of Rs. 15.7 crores was mainly to be contributed by other States. Although necessary steps were expected to be taken by States concerned to fulfil their obligations in this respect for successful implementation of the Second Plan, a recent assessment showed that the measures taken so far may yield about Rs. 2 crores only.

Taxation Enquiry Commission (1953-54)

16. The Taxation Enquiry Commission (1953-54) vide paragraphs 25-33 of Chapter VII of Vol. III of their report), supporting the levy have pointed out that the imposition of such a levy, would fulfil other desired objectives, namely (i) stabilisation of land value, and (ii) in the present context of increasing cost of construction and development, would provide additional resources to Governmen to liquidate, at least, a part of the capital cost of the project. They have dealt with the various aspects of the betterment levy namely, taxation of unearned increment in land value; maximum limit on betterment levy; period of payment; adjustment to price changes; and the case of minor irrigation works. The Commission made the following principal recommendations:—

(*i*) The quantum of the levy may be fixed at a maximum of 50% of the increase in value of land.

(*ii*) Its recovery should be spread over a reasonably long period.

(*iii*) It would be advisable for all States to provide specific relief in times of a steep fall in prices by way of postponement of instalments. In the event of a sustained and substantial rise in price, there is need for upward revision.

(*iv*) The tax cannot be imposed on certain type of minor works like wells, tanks, etc. There is, however, justification for an additional levy on tube-wells and some of the large schemes in this class. Even here, an appropriate method of recovery is to make a small increase in the water rate.

Opposition to Betterment Levy

17. Before proceeding further, let us now see what are the view-points and arguments generally advanced against imposition of betterment levy. Here are the more important ones:—

(*i*) The land under irrigation is already burdened under multiple forms of heavy taxation such as

(*a*) Water advantage rate;

(*b*) Surcharge and special charge on land revenue;

(*c*) Local rate-approximately 50% of the land revenue;

which collectively are much more when compared with the actual benefits.

(*ii*) The peasants supply wheat, rice, cotton and other food-grains at prices much lower than the market prices prevalent.

(*iii*) Certain crops such as cotton supplied at cheaper rates reduce the foreign exchange deficit of the country and Government's liability for subsidising the imported food-grains. This is, in a way, indirect monetary contribution of the peasants to Government.

(*iv*) The land is charged with water-tax which has been increased by 25% or 50%.

(*v*) The betterment fee is proposed to be levied on the commanded area which is improperly and unjustly assessed.

(*vi*) It is beyond the capacity of the peasant to pay this additional tax burden.

(*vii*) Some feel that the present time is not quite opportune to introduce new legislation of this nature.

(*viii*) The levy will be confined to new works and will yield revenue for a limited period. The revenue would be comparatively smaller than that from enhancement of water rates which source is perennial.

(*ix*) It would not be practicable to enforce this in view of the prevailing high prices and distress.

(*x*) Most of the holdings are non-transferable. Even if there is rise in the market value of land, it would not bring any additional income to the cultivator. His capacity to pay will depend upon the increase in the value of the annual produce from his land. It will thus be difficult to realise the betterment fees; and much spade and preliminary work will have to be done before any revenue can be realised.

(*xi*) Increase in irrigation rates may yield appreciable additional revenue and betterment levy need not be imposed simultaneously.

Present Position in Various States

18. On the basis of the progress so far made in respect of collection of, and legislation for, betterment levy, the various States may be categorised, broadly, as follows:

1. *States in which steps are being taken for collection of betterment charges*:

1. Andhra Pradesh
2. Assam
3. Bombay
4. Kerala
5. Madras
6. Mysore
7. Orissa
8. Punjab
9. Rajasthan

(ii) *State/Central Administration who have passed the necessary Act.*

10. Madhya Pradesh
11. Himachal Pradesh

(iii) *State which has prepared the Bill and is taking action towards enactment*

12. Bihar

(iv) *States/Central Administration with whom the matter has been under consideration*

13. Jammu & Kashmir
14. Uttar Pradesh
15. West Bengal
16. Delhi.

(v) *Central Administrations where the question does not arise owing to absence of major river-valley schemes or absence of a suitable case for levy*

17. Andaman and Nicobar Islands
18. Laccadive Islands
19. Manipur
20. Tripura
21. Pondicherry

It will be seen from the foregoing table that legislation or law has been passed in 10 States and in Himachal Pradesh, a Central Administration and the Bill has been prepared in one other State. Actual collection of betterment fees does not appear to have commenced till March '58 in any of the States other than Mysore where the practice has been in vogue for quite some years in the past.

Practice in Foreign Countries

19. In foreign countries such as USA, Australia, New Zealand, Egypt, South Africa, Italy and Spain, the practice of collecting or recovering part of, or full, capital cost invested on a project, from its beneficiaries is, generally referred to as 'Repayment Charges'. This is introduced by the Government or any other authorised body, by enactment of law such as "The Reclamation Project Act, 1939" in USA or "The Irrigation Amendment Act, 1941" in New South Wales (Australia).

20. In USA, a variety of systems of "Repayment Charges" are adopted:—

(*i*) Thosed based on uniform rate per acre;

(*ii*) Those based on the value of land when irrigated i.e. the Ad-Valorem method; and

(*iii*) Those made according to benefits received.

Districts of Arizonia, Colorado, Montana, New Mexico and Oregon adopt method (i) for some of the irrigation projects, not taking into account the productivity and the classification of the soil. The Irrigation Districts of California, Nebraska, Oklahama and Kansas assess these charges on the Ad-Valorem method (ii), the assessment varyng from $10 to $100 per acre. The benefits theory of assessment in (iii) above, is being applied in the States of Washington, Idaho and Nevada, North and South Dakota. In Columbia Basin in the North-West, however, no less than nine different degrees of benefits are recognized with an annual assessment ranging from $0.3 to $1.8 per acre.

21. Both Federal and State laws permit a variation in repayment charges. The Fact Finders' Committee appointed in 1924 examined the whole question of repayment and recommended certain changes in the then existing practices of assigning uniform construction charges per acre and in the length of the period of payment and their findings led to a system of differential payments related to productive earnings from the land. Annual construction charges were adjusted to gross income from land, subject to a maximum repayment period. The repayment charges on project lands are determined with due regard to the relative values of different farm units and, for each unit, a sum covering its proportionate share of construction costs will be arrived at. Unit allowances for costs to be incurred by settlers to prepare the land for irrigation will be taken into account. Attempts are then made to distribute the capital charges equitably among the project lands commensurate with the benefit they would receive from the project. After assessments are made, it is usual to allow a development period

averaging five years or so after the advent of irrigation facilities to enable the cultivators to improve their lands and realise benefits from irrigation.

22. The Irrigation Amendment Act, 1941, passed by New South Wales Government enforces that all benefited lands shall be ratable and a contribution towards the capital cost of the works of drainage, etc., at the rate of £8/acre shall be payable by all such ratable lands. This is applied to Coomella Irrigation-system. Similar Acts are in force in Murrambidges and Murry irrigation systems. In New Zealand, according to Water Supply Act of 1891, lands benefited under any project, shall have to pay a stipulated repayment charges towards the construction cost of the project.

23. In Egypt, payment for the cost of the Aswan Dam and correlated irrigation works on the Nile River is proportional to the rental value of the land. At the time of re-assessment to provide for payment of the works, the rental value of the land was determined and taken as the basis for the adjusted land tax. By a decree, the land tax was fixed for 30 years at 28.64% of the rental value of land. In addition, a supertax (of 50 piastres per fedden on lands irrigated by free flow and 30 piastres per fedden on lands irrigated by lift) is levied on lands irrigated from the Aswan Dam. In respect of smaller irrigation works, the law provides that if citizens of a village wish to construct an irrigation project on their own land, every one of them shall pay the costs of construction and maintenance, in proportion to the extent to which their land will be benefited by the project.

24. In South Africa, a significant departure from the uniform flat rate per acre, was made in Vaal-Harts irrigation scheme. Rates of all ratable areas in it have an Ad-Valorem base, namely, rates on a graduated scale, contingent upon the fair market value of the land. Market value is determined by the price at which any portion of the land in question has been sold during the 12 months preceding the date on which the rate is recoverable.

25. In Italy, on some projects, charges vary in accordance with crops produced. The following schedule was established for lands served by the Muzza Canal:—

(*i*) $8 per acre annually for rice;
(*ii*) $4.80 per marcite; and
(*iii*) $1.20 per irrigation for corn and March sown crops.

As early as in 1852, it was reported that payment for water was made on the basis of the gross produce for the land. Similar principle has been followed in the financing of reclamation works during recent years. A portion of the construction cost is borne by the Government and an association of land owners bears the remainder. Rembursement is made to the Association through the payment by the settlers, as a percentage of their produce.

26. In Spain, a variation of operation and maintenance assessments, was (and presumably still is) made in accordance with three classes of land, graded with respect to productivity. The assessment for the third class of land provides the basis for the others, that for the second class is twice the assessment for the third class, and that for the first class, thrice.

27. Coming nearer home, in the Thal area in Pakistan, the cost of projects carried out may be reimbursed in land. The State may recover the cost in accordance with the instalments and terms set for the buyers. This system is usually combined with the fixing of the maximum area that each property holder may have within the region benefited. The Punjab Thal (Increase in Value) Act, 1940 provided for the levy of a tax on lands the value of which would be enhanced by irrigation from the Thal Canal. According to this Act, betterment charges were to be recovered on the basis of a rate to be fixed by Government, limited to a maximum of Rs.30/- per acre which, it is understood, has subsequently been raised to Rs. 60/- per acre. This Act was simple in nature and the rates to be recovered in each case were to be fixed by Government.

Conclusion

28. Having dilated at some length on various facets of betterment levy, let us now see what are the issues that emerge from the foregoing discussion. In some States, although the law has been passed, there has been considerable delay in the collection of revenues through this levy. In a few others, even the legislative process appears to be taking unduly long time. In a State like Orissa, the scope of the Betterment Levy Act is at present not comprehensive in the sense that its application is confined only to the area beneficially served by the Hirakud Project. It is, however, understood that the Government of Orissa are, at present, taking action to apply the law to the whole of the State. In States like Punjab and Bombay where, it appears, revenues should have accured by now, it has been stated that there are procedural difficulties and bottlenecks in effecting realisations. Therefore are set out below some of the questions and issues that demand further attention and need looking into:—

(*i*) Examination and review of the existing Betterment Levy Acts and Bill so far prepared and other relevant Irrigation and allied Acts and the principles of scale of betterment levy adopted in different States and modification where necessary. Some of the criteria and clauses laid down in the legislation of States may need re-examination.

(*ii*) Examination of
(*a*) types of irrigation or water regulating works in respect of which the levy should be introduced

(*b*) basis and manner of assessing the levy

(*c*) method or procedure for collection of the fees

(*d*) when the recovery of levy should commence

(*e*) Whether the culturable command area or the area included within the irrigation boundary should be subjected to levy or it should be confined to only the area to be irrigated.

(*iii*) Examination of the introduction of a clause for recovery of payment of the levy in the shape of land at the option of Government.

(*iv*) What steps should be taken to speed up legislation where it has not been done?

(*v*) Making of a rough estimate of the total revenue in each State through betterment levy from projects included in the First and Second Plans, and their phasing of annual receipts.

(*vi*) Evolution of steps for removing procedural difficulties impeding timely collection and realisation of betterment levy.

Acknowledgements

29. The paper formed the basis of a lecture on the subject by the author at the Water Resources Development Training Centre, University of Roorke, in August '58. Permission to publish the paper in this Journal is thankfully acknowledged. In conclusion, it needs to be pointed out that whatever views have been expressed in this paper are the author's own and not of the organization or of the Government in which he serves.

ANNEXURE I.

Basis for Betterment Levy

I. *Dry lands converted into double-crop lands.*

It is assumed that the revenue obtained from the dry land prior to conversion is Rs. 100/-.

Increase in yield of paddy after conversion.	175 paras/acre
Taking the (average) price of paddy to be Rs. 1/4/0 per para value	Rs. $218\frac{3}{4}$
Increase in value = $218\frac{3}{4}$ — 100	Rs. $118\frac{3}{4}$
Capitalising this for 20 yrs. $118\frac{3}{4}\times 20$ =	Rs. 2375/-
The cost of conversion such as levelling, cutting channels, etc.	Rs. 775/-
Net increase = Rs. 2375—775 =	Rs. 1600/-
Betterment Levy = $\frac{1600}{4}$ =	Rs. 400/Acre

II. *Single crop lands converted to double crop lands*

Average present yield/acre	= 100 paras of paddy and Rs. 30 worth of graden crops
Future yield	= 175 paras/per acre
Increase in yield	= 75 paras/per acre
Value = 75 x 1	= Rs. $93\frac{3}{4}$
Increase in value	= $93\frac{3}{4}$—30 = $63\frac{3}{4}$
Capitalising this gross value	= $63\frac{3}{4}\times 20$ = 1275
Cost of conversion and field expenses	Rs. 375/-
Net amount	Rs. 900/-
Betterment Levy = $\frac{900}{4}$	= Rs. 225/-.

III. *Existing double crop lands (protected)*

Extra yield of paddy	= 25 para/acre
Value — $25\times 1\frac{1}{4}$	= Rs. $31\frac{1}{4}$
Increase in capital value Rs. $31\frac{1}{2}\times 20$	= Rs. 625/-
Cost of field channel and other expenses	= Rs. 65/-
Net amount	= Rs. 560/-
Betterment Levy $\frac{560}{4}$	= Rs. 140/-

The rates recommended for 3 categories of land noted above are Rs. 800/-, Rs. 445/- and Rs. 140/- per acre respectively.

ANNEXURE II.

Bhakra-Nangal proposed betterment levy

Type of irrigation	*Amount of betterment charges per acre of culturable commanded area included in the project in Rs.*	*Amount if made by instalments.*
Perennial	180	Rs. 8 per year during non-perennial stage and two half-yearly instalments of Rs. 8 during perennial stage; total instalments 30-
Restricted perennial	130	One instalment of Rs.5-12-0 per year during Kharif stage and two instalment of Rs. 5-12-0 per year during perennial stage.
Non-perennial	102	Thirty half-yearly instalments of Rs. 4-8-0 each
Grey Canals	0-51	Thirty half-yearly instalments of Rs.2-8-0 each.
Sirsa branch area	55	Thirty half-yearly instalments of Rs.2-8-0 each.
Chaggar Canal	0-90	Thirty half-yearly instalments of Rs. 3-0-0 each.
Sirhind Canal area on Punjab branches lying southwest of the the line joining Ferozepur with Jakhal	30	Thirty half-yearly instalments of Rs. 1-6-0 each.
Pepsu area lying southwest o f the line joining Ferozepur with Jakhal	84	Thirty half-yearly instalments of Rs.3-12-0 each.
Pepsu area ly.ng northwest of the line joining Ferozepur with Jakhal	25	Thirty half-yearly instalments of Rs.1-12-0 each.

Continued from page 24]

Impressions of My Tour Abroad

have been completely mechanized. Here, again, unless our land tenure system is radically changed and fragmentation of land holdings completely stopped, the use of equipment or any kind of integrated agriculture and irrigation cannot be thought of. Mechanization of agriculture would also not bring in problems of unemployment provided that mechanization is gradually introduced with the equipment manufactured in our own country. This will be apparent from the facts in the United States where the agricultural population has been gradually diminishing as more avenues of employment in industries are being opened.

(*f*) In fixing the priority of water use from the storage reservoirs, the U. S. Bureau of Reclamation has adopted the following order of priority:

(i) Domestic & Industrial use;
(ii) Irrigation;
(iii) Power;
(iv) Other uses.

(*g*) The system of appointment of reputed and experienced engineers as the Chairman and General Manager in the Tennessee Valley Authority has been mainly responsible for the efficient, economical and effective working of the single largest river valley development in the United States.

(*h*) It was observed that even though they are manufacturing a much larger quantity of cement every year they have done considerable research in the use of pozzolanic materials along with cement in the use of concrete for very important structures like Dams, locks and steam power stations.

(*i*) In Japan the cost of labour has been boosted up after the war to upgrade their standard of living. This has been possible only because the output of labour is comparatively high and the workers are more sincere, disciplined and loyal to their work.

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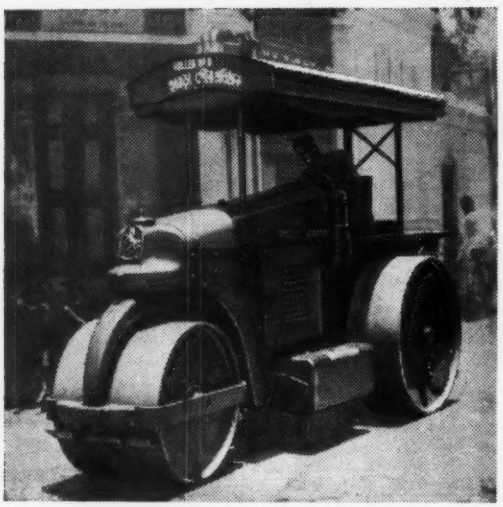

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Technique and Economics of Ripping

Substantial cost savings, more than one-third on typical jobs, can be realized by earthmovers who replace drilling and blasting with ripping.

By R. D. EVANS

Ripping cannot be called a science—no laws are available to predict exact results. Judgment, experience and trial-and-error are used mainly. And the economics of ripping, as compared to other methods have been well established.

The purpose of ripping is to break up hard masses so that the material can be handled more easily. Ripping for loading by tractor-scrapers appears to offer the best opportunity, but coal and frost ripping ahead of shovels promises to open many new applications.

Historically, ripping began with primitive man, who tore up the ground with picks and hoes. A wheeled plow, pulled by oxen, broke the ground ahead of shovelers and basket carriers on the Appian Way. The first modern units were also towed units, pulled by tractors, breaking up shale, limestone, hardpan and frost to increase scraper usefulness. These had three to five teeth and penetrated 15 to 30 inches, depending on tractor weight and horsepower. The recent trend is to tractor-mounted rippers.

Many specialized rippers have been built. One with a single tooth, can be pushed by a second tractor to obtain needed force and penetration. Pipeline and coal rippers have extra heavy frames and extra long teeth. Mountings, frame and body structures and controls made by various manufacturers are similar, but shanks, boots and points vary widely to meet field conditions.

The modern hydraulic ripper is mounted on the rear of the tractor. Constant power for raising and lowering the draft frame is provided by a pump driven off an engine live shaft. A clevis, mounted on the draft beam, holds the ripper shanks. In some types the clevis has a swivel action, easing tractor steering and permitting the shank to work around buried hard objects, reducing shock on the equipment.

The most important function of the clevis is to provide hole patterns for positioning the ripper shanks to meet the work at hand. Success or failure often depends upon proper depth and ripping angles.

Shanks fall into three categories—straight curved and modified. A straight shank can successfully handle a wide varietyof materials and penetration depths, due to its ripping angle and ability to stay down in blocky and slabby materials. Curved shanks work best on in non-slabby materials, where the lift action gives good fracture for effective scraper loading. Some shanks have been modified to obtain a more favourable penetration angle. All shanks are designed to keep frontal area to a minimum while maintaining necessary strength.

Ripper points, regardless of size and shape, must provide good initial penetration, good fracture characteristics and good wearability.

Apparently no two ripping jobs are exactly alike, but there are some general conditions that may be considered. First, the material must be "rippable". Sedimentary rocks, such as limestone, offer the best opportunity, but disintegrated or weathered solid formations, such as granite, can be ripped economically.

Moisture can aid ripping by preventing bonding between hard rock laminations, but can be a hindrance in some clay, sandstone and limestone formations.

End use—graded, fill or waste—should also be considered. Graded material will be crushed or sized. so ripping patterns must be varied accordingly. Fill materials must be broken sufficiently to meet maximum sizes of specifications and handling. Waste material need be loosened only enough to permit economical handling.

Ripping procedures also vary for transportation methods. For dozing, a minimum of passes is made to

With two teeth at full depth, a Caterpillar D9 Tractor with Cat No. 9 Ripper shatters hard rock.

give lowest costs. More passes must be made for smaller pieces for scraper loading. For loading by shovels, the material need be only smal enough for the bucket to handle. Ripped material for stationary conveyors should be sized to prolong belt life and for moving along inclined sections. For mobile conveyors, the material must be of a consistency that the loader can be pulled through it.

Now, how is ripping done? The tractor usually works in first gear to keep it from stalling on hard spots. Normally it is advantageous to start ripping with one tooth, adding more if the material is penetrated easily and breaks into satisfactory sizes. In slabby material, two or more teeth may act as a rake, reducing production.

In general, rip as deeply as possible. However, this may raise the rear of the machine off the ground or take too much weight off the front idler, reducing traction and production and increasing maintenance. Experimenting with ripping angles and depths is prudent.

Space between passes is governed by desired size. If full depth can be used, 3 to 5 feet is usually satisfactory. In crumbly material, use 6 to 8 foot spacings.

For scraper loading, rip in the same direction as loading. For quarries above a highwall, in slabby material work parallel with the wall to permit dozing off in rows. If the material is fractured, rip back from the face. Cross-ripping will break up material that slabs or channels.

In most applications, the direct drive tractor is more satisfactory than torque converter drive. It produces more positive pressure and shock loads to fracture and break out tough material. However, if the tractor will push load at least 50 percent of the time, a torque converter may be a better choice.

Ripping cost compared with blasting costs must be favourable to justify its use. Under typical conditions, a 320 H.P. diesel tractor with ripper and dozer can produce from 300 to 600 yards per hour. For the following comparision with blasting assume 100 yards production for both ripping and blasting.

The tractor sells for $53,000. Owning costs will be $8.21, operating costs $8.65. An operator will add $2.50, for a total of $19.36 per hour, or 19. 4 cents per yard.

A 600 cfm compressor, two 3-inch wagon drills, a 125 cfm compressor and a jack hammer—necessary for equal production—will sell for $28,000. Owning costs are $3.64, operating costs $4.63. Three drillers at $7.50, a powder man at $3.00 and a helper at $2.00 add $12.50 labor. Total hourly cost is $20.77, plus powder at 10 cents per yard. For 100 yards production, the cost would be 30.8 cents per yard, one third more than ripping costs. And the tractor can handle the loosened material.

Even greater savings have been realized by a Mesabi Range iron ore company. The material was clayey, sandy, boulder-strewn frost, considered "very tough

going" A four man crew of drillers and blasters required 5.4 shifts to adequately loosen 8100 square feet, five feet deep in frost.

A Caterpillar D9 Tractor, working an identical area, made four initial passes and one cross-ripping pass. The first layer was dozed off, and the process was repeated to reach the 5-foot depth. The D9 completed the 8400 square feet in 14 hours.

Drilling and blasting cost $728.15. Ripping cost $328.23. A savings of $397.92, more than half, was realized.

In general, it appears evident that ripping offers real opportunities for lower cost operations. Further trials will probably result in the extension of ripper economies to new fields.

TABLE I

TYPICAL RIPPER VS. BLASTING COMPARISON

EQUIPMENT SPREAD

Ripper			*Blasting*		
320 HP diesel tractor equipped with ripper and dozer			1 — 600 cfm compressor 2 — 3 inch wagon drills 1 — 125 cfm compressor 1 — Jack Hammer		
List Price —	$53,000		$28,000		
Hourly Cost					
Owning					
Depreciation	6.62			2.80	
Int. Ins & Taxes	1.59			.84	
		8.21			3.64
Operating					
Fuel	1.68			1.25	
Gas	.03			.03	
Oil & Filters	.32			.35	
Repairs. inc. Labour	6.62			3.00	
		8.65			4.63
Labor					
1 Operator	2.50		3 Drillers	7.50	
			1 Powder Man	3.00	
			1 Helper	2.00	
		2.50			12.50
		$19.36			$20.77
Cost of Powder†			$10 per yard		
Cost per Yard*					
$19.36 / 100 = 19.4 cents			$20.77 / 100 = 20.8×10 =		30.8 cents

† Assume that 1/2 pound of powder is required to blast one yard of rock and that powder costs $18.70 per 100 pounds.

* Assume that ripper production is 100 cubic yards per hour.

Comparing the cost of ripping of 19.4 cents per yard with 30.8 cents per yard for blasting, ripping would cost about 1/3 that of blasting.

TABLE II

RIPPING VS. DRILLING AND BLASTING IN FROST

CASE I

Data Supplied By : A Mesabi Range Iron Ore Mining Company

Material : Clayey, sandy, boulder-strewn frost — imbedded boulders upto one yard diameter "very tough going."

Area : Level surface, 180′ × 45′ = 8100 sq. ft.

Method : Small diameter, self-propelled, crawler-mounted, air-powered drill.

Hole spacing : 6′ × 5′ = 30×9 = 270 holes (5′ depth)

Shift : 8 hours — gross

Production : "Conservatively" 50 holes per shift—5.4 shifts required.

Labor Required : 5.4 Shifts Driller 2nd	@ $19.20 =	$103.68	
5.4 Shifts Driller Helper	@ $18.16 =	98.06	
1 Shift Blaster	@ $20.24 =	20.24	
1 Shift Blaster Helper	@ $17.12 =	17.12	
		$239.10	$239.10
Explosives Required :		345.00	345.00
Machine Expense : 5.4 × 8 = 43 hours of Air-Trac Drill	@ 3.35	144.05	144.05

Estimated cost of Drilling and Blasting "Hard Frost" Area = $728.15

Estimated cost of Ripping — Same area and material

Method : D9 Tractor and Ripper
4 initial passes and one cross-ripping pass.
Doze off first layer and repeat process once.

Production : 14 hours to rip 8100 sq. ft. area

Labor Required : 14 hours — tractor operator	@ $2.445 =	34.23
Machine Expense : Rate for D9 & Ripper — repair & maintenance, depreciation, supplies etc. — @21.00/hr. — 14 Hrs.	@ $21.00 =	294.00
Estimated cost of Ripping "Hard Frost" Area =		$328.23
Savings		$397.92

SHRI KANWAR SAIN RETIRES

Shri Kanwar Sain, I. S. E., M. I. E., after 36 years of highly distinguished service to the Nation in the field of Engineering and Water Resources Development, proceeded on leave on 15th October, 1958 preparatory to retirement from his present post in the Government of India.

Born on January 2, 1899, Shri Kanwar Sain was appointed to the Indian Service of Engineers in 1923 and has held very many important posts in various capacities both in the Government of Punjab, in the Government of the then Bikaner, and in the Government of India. His association with engineering works both within the country and abroad are unique. His extreme intelligence and wisdom, excellent forethought has been responsible for the conception and planning more then of 40 big Irrigation and Power Projects in the than joint Punjab and execution of some of them. The huge Rajasthan Canal Project, which is under construction today was conceived by him in 1948. He shouldered the responsibility, in varying degrees, in the planning, designs and construction of single and multipurpose projects all over India, under the first and second Fiver Year Plans. No major Project has escaped his attention and valuable advice. Mention may be made of Sulemanki, Panjnad, Trimnu and Kalabagh head-works, Haveli, Thal and Taunsa Pojects, in his earlier career, Bhakra-Nangal, Hirakud, Kosi, Nagarjunasagar, Damodar Valley Projects, etc. in the last 10 to 15 years.

Shri Kanwar Sain's association with the Central Water & Power Commission for the last 10 years has been a series of memorable events to the organisation. Expanding the organisation including a specialised Central Designs unit, systematic surveys of the country's Irrigation and Hydro-power potentials, load surveys, long range investigation for future water utilisation projects, national plans for flood control, setting up of plant and machinery units for co-ordinating the requirements of heavy equipment for the river valley projects—all were given a fillip by him during his term of office. The total sterngth of 2140 of the Central Water & Power Commission when he took over as Chairman in June, 1953, is today 4625.

Apart from his overall responsiblity for the functions and adhoc assignments of the Commission, his sevices have been tapped by other engineering organisations within the country and also abroad. As President of the Central Board of Irrigation & Power (1953), President, Institution of Engineers (India) 1956-57, Vice-President of the International Commission on Irrigation and Drainage 1954-57, and as Chairman of River Commissions, Technical Committees and Commissions, Member Control Boards, he has made invaluable contribution in the field of engineering.

£2,500,000 INDIAN RAILWAY CONTARCT FOR BICC GROUP

The BICC Group has been awarded a contract by the Indian Railway Board for the design, supply and installation of 25kV 50-cycle, single-phase A. C. overhead equipment. The approximate value of the contract, obtained against keen international competition, is £2,500,000 of which about 60% will be spent in Indian currency on locally manufactured materials and the local staff and labour costs, while about 40% will be in materials to be supplied from the U.K.

The lines to be equipped are near Calcutta on the main line to Bombay on the South Eastern Railway; they lie between Tatanagar and Rourkela, together with the branch from Rakharswan to Dongaposi. The length of track to be electrified is about 420 miles and the route links the iron ore fields in Bihar with the existing steel plant at Tatangar and the new plant under construction at Rourkela.

The copper catenary and contact wire will, in most cases, be supported from steel masts by means of hinged cantilevers which allow along-track movement. The tension in the conductors will be kept constant by means of balance-weights, thus given a level contact wire suitable for good current collection at high speeds.

The Indian Railways have decided to standardize their future electrifications on the 25kV 50-cycle single phase A. C. system. Previoulsy, lines in the Bombay district were equipped for 1,500-volt D. C. operation and in the Calcutta area lines were equipped for 3,000-volt D. C. operation. The overhead equipment for over 500 track miles of the lines in the Bombay area was designed, supplied and erected by the BICC Group who also supplied and installed the power and communications cables on the 3,000-volt D. C. system in the Calcutta area.

Work on the new contract is to begin immediately and is due to be completed in June 1960.

L. R. PATEL

Mr. L. R. Patal has been appointed, as from the lst January 1959, to the Board of Directors of Messrs. William Jacks & Co. Ltd., London, who do extensive business in industrial and heavy equipment closely allied to India's Development Plans in India, Pakistan, Burma and Hongkong and have associated and subsidiary companies in Malaya, British Borneo and Ceylon.

Mr. Patel will centinue to reside in India and look after the Company's business in India in his capacity as Director and Chief Manager in India.

Born in Baroda in 1907.

Joined William Jacks & Co., then a private partnership company, at Karachi, at the end of 1929; was transferred to the Calcutta Office the following year to develop the sale of tractors and agricultural equipment.

The Company became a Public Limited Company incorporated in U. K. in 1947.

Mr. Patel became Manager of the Calcutta Branch in 1949 and was appointed Chief Manager in India in 1957.

Mr. Patel has been a Mamber of the Executive Committee of the Calcutta Import Trade Association for several years and has been the Association Chairman for the years 1956, 1957 and 1958. He was also Chairman of the Tractor & Allied Equipment Manufacturers and Importers Association Ltd., of Bombay for two years in succession, i.e. 1956-57 and 1957-58.

Mr. Patal is also a Member of the Import Advisory Council of the Government of India.

Disease of Giantism

On the occasion of the twenty-sixth annual meeting of the Central Board of Irrigation and Power, Pandit Jawaharlal Nehru made some significant remarks about the prevailing tendency and attitude of mind among our leading men. It would not be correct to say that these remarks apply only to the engineers in the country. It applies equally to our other specialists and administrators as well as to the politicains. He referred to "this disease of giantism—showing off that we can do big things". He made it clear that he was not against undertaking big tasks but he definitely disliked doing so "for the sake of bigness".

But as the Prime Minister was addressing the audience composed primarily of engineers engaged in power and river valley projects, it may create an impression that the disease primarily originated from and is prevalent among the class of engineers. That would not be a correct reading of the situation; because it is common knowledge that the disease is widespread in all sectors of the nation's elite. The engineers are not the only persons responsible for selecting major valley projects for inclusion in the country's development plans. Who does not know that there is today a feverish race between State Governments to get larger and larger projects sanctioned by the Planning Commission as a measure of greatness and rapid advance? By this we donot mean that the engineers are completely free from this disease. As a part and parcel of the community's leadership they are equally affected by the virus. It may be remembered that we had referred to this unfortunate trend on several occasions in these columns. We are happy, therefore, that our Prime Minister was thinking aloud and helped to raise the issue provokingly.

In the absence of a widespread and alert intellectual life among the elite, it is likely that now there will be a swing in the other direction, namely, an enthusiastic demand for small projects and severe condemnation of large projects even if they be necessary in a given context. This will be so because the new fashion has now been set by our Prime Minister.

But whether a given problem can be met by small projects or large or a combination of both can be decied only by a sober assessment of the problem itself. Take for example the question of agricultural production. It is the crisis in this field that has led to the recent heart-searching.

The fierce race between population growth and increase of agricultural production is on. The total production of agricultural commodity, mainly the food is to be stepped up. This increase can be undertaken both by increasing the total acreage as well as the productidity per acre. It is in this context that irrigation policy for the country is to be discussed, A fuller consideration of the irrigation needs of the country to meet the agricultural production problem will show that we need not only minor and medium projects but also some major ones if we are to maintain a developing momentum in the rate of increase in the acreage under irrigation. It would be wrong and even suicidal to believe that we can exclude major irrigation projects altogether. We have made mistakes in laying too much stress on them in the earlier years. What we need today is an integrated long-term programme of a combination of all the three categories of irrigation projects.

Now that we are in the midst of an agricultural crisis, there is a tendency to put the blame on somebody without carefully examining whether he is to blame for the entire miscarriage of policy or whether the formulation of policy was wrong, or both. Irrigation by itself is not the only factor in promoting agricultural productivity. Fertilisers, better seeds and improved agricultural implements are equally necessary. Land reforms have been crying out for execution all these years. Rural roads, marketing facilities. credit are other needs to provide the necessary incentive and organisational impetus for increased productivity. Where are they? Haven't we been too niggardly in our approach to these social and economic projects? If side by side with irrigation projects these other conditions were created, the productivity in agriculture would have by now been an accomplished fact. Unfortunately our psychology has been so developed that the word 'bigness' is associated in our minds with visually large-size *things*. If on the other hand, we could reorient our minds and we associated this very word with end results, and planned our resources and our efforts from this point of departure, we certainly would have achieved much better results and avoided the crisis which we are in.

But while our Prime Minister diagnosed the disease in us correctly, we should not falter here in stating that he considerably contributed to the emergence of this mental makeup. He has been all these years the guiding spirit behind our development plans. Perhaps he did not mean it. But the spirit engendered in the past, albeit unknowingly, has reared its ugly head as a hydraheaded monster in so many States.

While talking of bigness of projects we should like to draw the attention of the country to a really major problem which can be tackled only in a big way. It is the problem of soil erosion. We have written about it times without number. The foresters and the soil conservationists have cried hoarse about the danger that faces us if we refuse to see the enormity of the problem. Even Prof. Thacker who delivered the presi-

dential address at the C. B. P. I. meeting referred to the problem of silting of reservoirs due to soil erosion. But somehow or other this problem has never been faced boldly and in a manner befitting its stature.

But the Prime Minister rightly stated that "We shall have to undertake big things in our country because it is big and our needs are big. We should always remember, however, that it is the ten thousand small tasks that initially count". If we put the programme of soil conservation and afforestation in this context, we shall then be able to understand what is the meaning of big tasks in the Indian context.

When all this is said and done, it still remains to discuss why and whence this craze for bigness. This is not peculiar to India. It is there in USA as well as USSR. The difference between them and ourselves is that we cannot afford it, whereas they may. It would not be a proper place to discuss the psychological and philosophical aspects of the causes. But we do think, that Pandit Nehru, sensitive and aesthetic individual that he is, inspite of the hero and the politician in him, has very correctly spotted the most critical of the symptoms of our deeprooted ailment.

Our Contributors

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Prof. K. Seethramiah, is Assistant Professor in the Indian Institute of Science, at Bangalore. He has been a frequent contributor to our Journal and is a member of the American Society of Civil Engineers, of I.A.H.R. British Hydro Dynamic Research Association, Society of Power Engineers in India and Associate Member of the Institute of Engineers. He has a wide technical experience having worked in Jog Power Scheme, Chambal Hydel Scheme, Radhanagari Hydro Project and Koyna Hydro Project since 1951. He has been teaching Post-Graduate students in the Institute, in the Department of Power Engineering. He has a large number of papers to his credit and wide experience having visited practically all the major power projects in U.S.A. and Europe.

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Printed and published by P. K. Menon from Inland Printing Works 60/3 Dharamtala Street, Calcutta 13
Editorial & Managerial Office : 6/2 Madan Street, Calcutta 13

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VOL.58.BA

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